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ABSTRACT

The Science 16 program provides for the development of essential concepts, skills, and attitudes in science that will enable students to function successfully in the home, classroom, workplace, and community. The program is activity-based, and provides opportunities for students to relate essential concepts, skills, and attitudes to their own world of experience and needs. Societal issues involving science and technology have been integrated throughout the program. Community partnerships provide opportunities for students to become involved in the community by way of meaningful activity linked to the science program. Strategies and skills for scientific inquiry, problem solving, and decision making included throughout the Science 16 program provide students with a systematic and logical approach for dealing with a variety of phenomena encountered in their environment. This manual has been developed to assist classroom teachers to implement the Integrated Occupational Science 16 program. This manual should be used as a practical planning and instructional tool in translating the intentions of the Science 16 program. Contents include: (1) further information about the goals and objectives of the science program; (2) thematic contexts for the delivery of prescribed concepts, skills, and attitudes; (3) suggestions for planning and implementing the program; (4) suggestions for relating science instruction to essential life skills; (5) suggestions for using community resources to provide instruction in science; (6) situational and concrete approaches for developing an understanding of the interactions among science, technology, and society; (7) suggestions for developing thinking and communicating skills; and (8) suggestions for assessing and evaluating student progress. (KR)

ED325305

INTEGRATED OCCUPATIONAL PROGRAM

Teacher Resource Manual

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SCIENCE 16

INTERIM – 1990

SE 051 640

CURRICULUM

Alberta
EDUCATION

Teacher Resource Manual

Science 16

INTERIM – 1990

NOTE: This publication is a service document. The advice and direction offered is suggested only. Consult the Program of Studies/Curriculum Guide to identify the prescriptive contents of the Science 16 Program.

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ASSOCIATE DIRECTOR: A. A. (Scotty) Day

INTEGRATED OCCUPATIONAL PROGRAM MANAGER: Michael Alpern

PROGRAM MANAGER, SCIENCE: Gary Bertrand

CONTRIBUTING WRITER: Deborah MacFadyen

INTEGRATED OCCUPATIONAL PROGRAM TEAM:

Jeanne Cooper
Lorraine Crawford
Marilyn Dyck
Linda Elliott
Jan Marvin
Kathy McCabe
Paul McNair

INTEGRATED OCCUPATIONAL PROGRAM REVIEW COMMITTEE:

Stuart Adams	– County of Strathcona No. 20
Pat Boon-Anderson	– Lac La Biche School Division No. 57
Christopher Harrison	– Alberta Vocational Centre, Edmonton
Ed Holt	– Conference of Alberta School Superintendents
Alex McCaughan	– Alberta Education
Wayne Nixon	– Alberta Career Development and Employment
William Smolak	– Alberta Teachers' Association
Doug Tarney	– Wetaskiwin School District No. 264

EDITING: Elizabeth McCardle

DESKTOP PUBLISHING: Esther Yong
Dianne Hohnstein

ILLUSTRATIONS: Kelvin Ogden

SECRETARIES: Rita Flint
Marcie Whitecotton-Carroll

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INTRODUCTION

PURPOSE

This *Teacher Resource Manual* (TRM) has been developed to assist classroom teachers to implement the Integrated Occupational Science 16 program. Teachers are encouraged to use this manual as a practical planning and instructional tool in translating the intentions of the science program, as outlined in the *Science 16 Program of Studies/Curriculum Guide*, into classroom practice. Although shaded statements or segments within this manual indicate prescriptive content of the program of studies, all other advice and direction provided are suggested only and are not legally binding.

This TRM provides:

- further information about the goals and objectives of the science program
- thematic contexts for the delivery of prescribed concepts, skills and attitudes
- suggestions for planning and implementing the program
    - instructional strategies
    - sequenced activities
    - a correlation of strategies and activities to learning resources
- suggestions for relating science instruction to essential life skills and other applications across the curriculum
- suggestions for using community resources to provide instruction in science
- situational and concrete approaches for developing an understanding of the interactions among science, technology and society
- strategies for organizing thought and action when conducting scientific inquiry, solving problems and resolving societal issues
- suggestions for developing thinking and communicating skills
- suggestions for assessing and evaluating student progress.

The binder format was chosen for this manual to enable teachers to add strategies, samples of student work and other activities that have through experience, proven effective. During cooperative planning sessions, pages may be easily removed and shared with other Integrated Occupational Program teachers. This exchange will increase awareness of content in other subject areas, thereby providing additional opportunities for students to relate science competencies to applications in everyday life, the occupational courses and other academic disciplines.

HOW TO USE THE TEACHER RESOURCE MANUAL

This manual has been organized to provide ready access to both thematic units and suggestions for addressing program emphases and methodology within the Science 16 program.

THEMES

Four thematic units of instruction that assure coverage of the concepts, skills and attitudes prescribed for Science 16 have been placed at the beginning of this manual. The themes can be accessed by using the tab to the right of the manual.

The chart below provides the titles of themes developed for Science 16, and illustrates their relationship to themes developed for Science 26.

	SCIENCE 16	**SCIENCE 26**
Theme A **LIFE FORMS AND CHANGES**	SYSTEMS OF THE HUMAN BODY	PERSONAL HEALTH AND LIFESTYLE
Theme B **USING MATERIALS AND PRODUCTS**	CHEMISTRY FOR THE CONSUMER	MATERIALS WE USE
Theme C **TECHNOLOGY AT WORK**	USING SYSTEMS AND TECHNOLOGIES	TECHNOLOGY IN TRANSPORTATION
Theme D **UNDERSTANDING OUR ENVIRONMENT**	MANAGING ENVIRONMENT AND RESOURCES	ENERGY AND THE ENVIRONMENT

Teachers are encouraged to examine each theme and its corresponding activities and learning resources well in advance of instruction. The activities and suggestions provided within each theme are numerous. Advance planning should include a synthesis of effective strategies from the teacher's repertoire of personal experience, together with the suggestions in this manual considered most appropriate to student needs.

PROGRAM EMPHASES AND METHODOLOGY

Suggestions for addressing program emphases and methodology within the Science 16 program are provided in the five sections that follow the themes. These sections of the manual, which can also be accessed by using the tabs, are:

- Nature of Science.
- Science and Technology.
- Science, Technology and Societal Issues.
- Communication Skills,
- Assessment/Evaluation.

Each of these sections clarifies the intent of a particular component of instruction, and suggests teaching practices that will assist students to acquire an understanding of prescribed concepts, skills and attitudes. Teachers are encouraged to reference the ideas provided throughout these sections of the manual as they plan learning activities within each theme of the science program.

PROGRAM PLANNING

GENERAL COURSE PLANNING

Themes and their subsequent concepts, skills and attitudes may be sequenced at the teacher's discretion. Program planning should take into consideration the developmental nature of concepts and skills in science, as well as students' interests, abilities, and preferred ways of learning. The four themes provided in this manual are intended to be descriptive rather than prescriptive. Teachers may choose to modify these themes to address individual student needs.

Through cooperative conferencing, teachers may find that students are required to use certain science-related competencies in other courses before they are learned in science class. Joint planning and negotiation with teachers of other courses will be required to establish an integrated program that places consistent expectations upon the student.

Program planning must place emphasis on developing an understanding of the nature of science, as well as an understanding of the dynamic relationships that exist among science, technology and society. Instructional activities must also support the development of thinking skills. A focus on appropriate strategies for conducting scientific inquiry, solving problems and making informed decisions will assist students to develop systematic and logical approaches to deal with the variety of phenomena encountered in their environment.

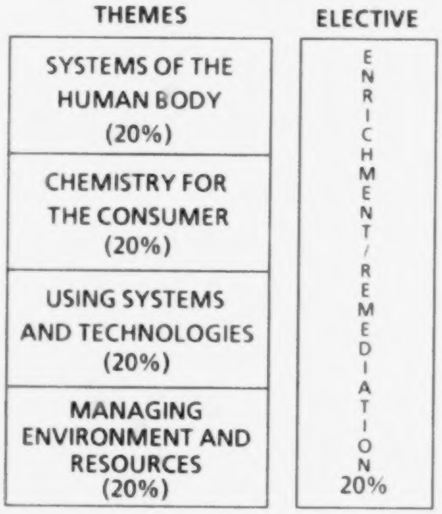
The suggestions and ideas provided throughout this manual, while numerous, are by no means exhaustive. Be prepared to add, delete and modify activities in adapting a theme to the particular circumstances of the classroom and student.

TIME ALLOCATIONS

As a 3-credit course, Science 16 is designed to be taught through 75 hours of instruction. In meeting student needs, however, local jurisdictions may find it desirable to allocate additional time for instruction in I.O.P. science. (For example, schools may offer this 3-credit course through 125 hours of instruction.)

Time allocations for the delivery of themes are suggested below. These suggestions are intended to provide guidance only. Teachers may wish to vary and adjust the allocation of time among individual themes to address students' interests, abilities and needs.

Systems of the Human Body	20%
Chemistry for the Consumer	20%
Using Systems and Technologies	20%
Managing Environment and Resources	20%
Required Time	80%
Elective Time	20%
Total	100%


THEMES
ELECTIVE
SYSTEMS OF THE HUMAN BODY (20%)
CHEMISTRY FOR THE CONSUMER (20%)
USING SYSTEMS AND TECHNOLOGIES (20%)
MANAGING ENVIRONMENT AND RESOURCES (20%)
ENRICHMENT/REMEDIATION 20%

RELATIONSHIP OF SCIENCE 16-26 TO SCIENCE 14-24

RATIONALE

As outlined in the *Guide to Education: Senior High Handbook* (1989-90), Science 16 is designed to allow students to meet the credit requirements of the Certificate of Achievement. Science 26 is optional, allowing students to develop further their knowledge and skills in science, and facilitates transfer to the General High School Diploma program. In contrast, the Science 14-24 program is designed to allow students to meet the credit requirements of the General High School Diploma.

CERTIFICATE OF ACHIEVEMENT (80 credits)			*GENERAL DIPLOMA TRANSFER*
Grade 10	Grade 11	Grade 12	
English 16 (3)	English 26 (3) →	English 36 (3)	*English 23→33 (5,5)*
Mathematics 16 (3)	*Mathematics 26 (3) →		*Mathematics 24 (3,5)*
Science 16 (3)	***Science 26 (3)** →		*Science 24 (3,5)*
Social Studies 16 (3)	Social Studies 26 (3) →		*Social Studies 23, 33 (5,5)*
Occupational 16 (3,5)	Occupational 26 (10) →	Occupational 36 (10)	*Vocational 22, 32 (5, 10, 15, 20)*

* Mathematics 26 and **Science 26** – These courses are designed to prepare students for possible transfer to the General High School Diploma route. While not required as part of the Certificate of Achievement, I.O.P. students may choose to enrol in these course and may apply the credits as part of their unspecified course requirements (13 credits)

Both Science 16-26 and Science 14-24 have been developed on the basis of their appropriateness to the developmental levels of students. Both programs, however, provide potential for students to transfer to higher level science courses. Similarly, in both programs, the utility and application of concepts and skills in science provide a focus for instruction.

COURSE DESIGN

Both Science 16 and Science 14 are activity-based, and use themes to provide practical learning opportunities and experiences. The themes establish a context for the integrated development of concepts, skills and attitudes. Student learning resources used in both Science 16 and Science 14 are common and support the instructional design of each course.

PROGRAM EMPHASES

Learner objectives stated in the Science 16 Program of Studies and the Science 14 Program of Studies indicate that these programs parallel one another in the emphasis placed on developing an understanding of:

- science as a disciplined way to develop explanations for natural phenomena
- the interaction between science and technology
- how science and technology influence and are, in turn, influenced by societal issues.

Thinking skills appropriate to conducting investigations and solving problems are integrated throughout both Science 16 and Science 14.

CONCEPTS, SKILLS AND ATTITUDES

Concepts developed in Science 16 are similar to those developed in Science 14; both contribute to an understanding of major ideas in the natural sciences. Learning objectives in Science 16 focus on developing an operational understanding of science as it relates to relevant and concrete situations. In Science 14, there is a similar practical and concrete orientation; in this course, however, students are encouraged to extend their thinking about science to more abstract levels.

In both Science 16 and Science 14, thinking skills are developed through the investigation of natural phenomena, problem solving and informed decision making. In Science 16, thinking skills are developed through structured learning experiences. Science 14 encourages a more independent application of thinking skills through research.

In both courses, students are encouraged to develop attitudes that enable them to:

- successfully study and practise science
- appreciate the impacts of science in society.

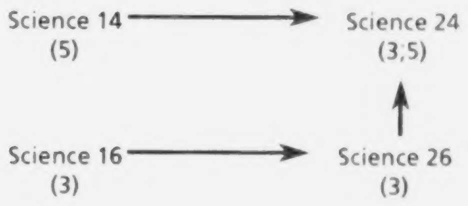
COGNITIVE DEMAND

Cognitive demands in the two programs differ in the level of analysis and abstract thought processes that students are expected to use. Applications in Science 16 generally focus on the transfer of concepts, skills and attitudes to daily life and work-related situations. Many of the applications in Science 14 encourage students to use concepts, skills and attitudes in more complex situations.

Cognitive demands in these programs will be further influenced by the needs and abilities of individual students.

TRANSFERABILITY

Although content in Science 16 is less complex than the content in Science 14, the Science 16-26 course sequence will develop concepts, skills and attitudes that facilitate transfer from Science 26 to Science 24. Program sequences and recommended transfer points are illustrated below.



Additional information about transfer routes from the Integrated Occupational Program to the General High School Diploma program is provided in *Guide to Education: Senior High Handbook* (1989-90).

SCOPE AND SEQUENCE FOR SCIENCE 16-26

The scope and sequence chart provided on the following pages outlines the concepts, skills and attitudes that are addressed throughout Science 16 and 26. As students differ in the rate at which they acquire competencies in science, the chart is intended to assist teachers in assessing present levels of student performance, and in diagnosing individual strengths and weaknesses.

In using the scope and sequence, it should be noted that:

- **attitudes and skills are developmental through Science 16 and 26** (i.e., the spiral approach). Students will refine and extend the attitudes and skills developed in Science 16 through more extensive applications in Science 26.

- **concepts developed in the Science 16 program are in most cases discrete from concepts developed in the Science 26 program.** Effort has been made to apportion concepts throughout Science 16 and Science 26 on the basis of their cognitive demand.

- **the attitudes, skills and concepts are interdependent at each grade level, and are not meant to be developed in isolation.** Although some concepts and skills may be mastered more effectively through discrete instruction, this approach is not advocated as a primary focus of instruction. The thematic structure permits a holistic view of instruction through the linking of strategies and skills.

- most students will continue to use concrete operational thinking, depending upon personal and tangible experience in order to link ideas. **Instruction should generally begin with an operational understanding of ideas at the Science 16 level, and encourage students to extend their thinking to more abstract levels that are cognitively appropriate at the Science 26 level.** (The *Teacher Resource Manuals* for Science 16 and 26 provide for the development of thinking skills through themes that reflect increasing levels of analysis and critical thought.)

Teachers are encouraged to examine the scope and sequence chart for the I.O.P. Junior High School Science Program (Grades 8 and 9). An understanding of the developmental progression of concepts, process and skill occurring in Grade 8 and Grade 9 will facilitate articulation between the junior high and senior high science programs.

<table>
<tr><th></th><th>SCIENCE 16
SYSTEMS OF THE HUMAN BODY</th><th>SCIENCE 26
PERSONAL HEALTH AND LIFESTYLE</th></tr>
<tr><td>ATTITUDES</td><td colspan="2">Students will be encouraged to:
• display a positive attitude toward the learning of concepts and skills in science
• appreciate the intricate workings and balance within the human body
• appreciate the contributions of science and technology to human health
• value knowledge gained for its usefulness on a personal level
• appreciate the need for informed decision making at both personal and societal levels
• appreciate that ethical dilemmas may arise from the application of scientific research and/or medical technologies
• display responsible attitudes toward personal health through nutrition, exercise, safety and lifestyle.</td></tr>
<tr><td>SKILLS</td><td colspan="2">Students will be expected to demonstrate an ability to:
• collect data related to critical life functions and body systems through observation, interview and/or research
• design an experiment, through class discussion, that illustrates the use of a technology in monitoring variations in the functioning of a body system
• use selected monitoring technologies in collecting data about personal health and fitness factors
• analyze and assess personal health and fitness factors by identifying relationships, by considering consequences, and by examining a variety of viewpoints
• infer potential threats to personal health that may be caused by lifestyle factors
• apply the results of investigation to personal situation, identifying appropriate strategies for monitoring and maintaining personal health.</td></tr>
<tr><td>CONCEPTS</td><td>Students will be expected to demonstrate an understanding that:
• the human body is a product of a number of body systems working together to perform critical life functions
• each body system has specific structures that enable it to perform a critical life function
• functional relationships among systems of the human body are critical to life
• medical technology can be used to monitor body conditions and personal health factors
• interrelationships exist between nutrition, level of fitness and personal health
• societal issues may arise from the use of technologies in preserving balance among systems of the human body.</td><td>Students will be expected to demonstrate an understanding that:
• personal diet should include minimal amounts of certain foods in order to maintain health
• much of our food, particularly processed food items, contain additives
• drugs, alcohol and tobacco may affect nutritional requirements and cause related disease
• a relationship exists between caloric intake, energy output and body weight
• physical exercise will assist in maintaining cardiovascular and respiratory health
• emotional factors can have both positive and negative effects on personal health and well-being
• interrelationships exist among a variety of lifestyle factors (e.g., diet, exercise, substance use/abuse, stress) and personal health.</td></tr>
</table>

USING MATERIALS AND PRODUCTS

<table>
<tr><th></th><th>SCIENCE 16
CHEMISTRY FOR THE CONSUMER</th><th>SCIENCE 26
MATERIALS WE USE</th></tr>
<tr><td>ATTITUDES</td><td colspan="2">Students will be encouraged to:
• display a positive attitude toward the learning of concepts and skills in science
• value scientific principles and processes for their usefulness in providing explanations of everyday phenomena
• appreciate the usefulness of measurement skills in real life and work-related situations
• appreciate the role of technology in solving practical problems
• appreciate the usefulness and potential hazards of common household materials
• display a respect for personal safety and the safety of others when handling potentially hazardous materials
• appreciate the contributions of science and technology to the development of a variety of materials and products that we depend upon and use each day.</td></tr>
<tr><td>SKILLS</td><td colspan="2">Students will be expected to demonstrate an ability to:
• conduct experiments that illustrate the properties of familiar substances and materials
• design experiments, through class discussion, that illustrate predictability in the behaviour of substances and materials that are investigated
• effectively use apparatus and equipment when conducting experiments
• make qualitative and quantitative observations when conducting experiments
• identify patterns and relationships in the behaviour of substances and materials, and use this information to explain the application of particular consumer products in everyday situations
• predict heat exchange in practical situations, and use appropriate procedures for protecting living organisms and other materials from excessive heat transfer
• accurately read product labels and consumer reports in order to determine the composition and intended use of familiar household products
• apply appropriate techniques for identifying acids, bases and other hazardous substances
• use safe procedures for handling and storing potentially dangerous substances.</td></tr>
<tr><td>CONCEPTS</td><td>Students will be expected to demonstrate an understanding that:
• the properties of household solutions are different from those of pure substances
• permanent suspensions have useful properties and a variety of applications in the home
• acids and bases have useful properties and a variety of applications in the home
• solubility varies with temperature
• many chemical reactions may require or emit energy in the form of heat
• heat flows from areas of high temperature to areas of lower temperature
• handling, storing and using potentially hazardous chemical products requires knowledge and care.</td><td>Students will be expected to demonstrate an understanding that:
• the properties of the materials and products we use are determined by their composition
• models and other conceptual inventions are useful in explaining the composition and behaviour of matter
• materials and products are derived from both natural and synthetic materials
• the properties of materials determine their suitability for particular applications
• our use of natural and synthetic materials affects both environment and resources
• the process of biodegradation reduces the impact that some products have on the environment
• science and technology assist in solving practical problems and responding to environmental issues by developing new materials.</td></tr>
</table>

<table>
<tr><th></th><th>SCIENCE 16
USING SYSTEMS AND TECHNOLOGIES</th><th>SCIENCE 26
TECHNOLOGY IN TRANSPORTATION</th></tr>
<tr><td>ATTITUDES</td><td colspan="2">Students will be encouraged to:
• display a positive attitude toward the learning of concepts and skills in science
• appreciate the roles of science and technology in serving human needs, and the usefulness of technological problem-solving skills in finding solutions to practical problems
• develop confidence in personal ability to understand and solve practical problems through the use of science and technology
• display concern for safety when using technological products and processes
• appreciate that ethical dilemmas may arise from the application of scientific research and/or technological developments
• appreciate the relationships among science, technology and society.</td></tr>
<tr><td>SKILLS</td><td colspan="2">Students will be expected to demonstrate an ability to:
• observe and analyze the operation of familiar devices and systems, identifying component parts and scientific principles that are used
• prepare systems diagrams that illustrate how component parts and/or subsystems within a technological device work together in accomplishing a task
• test and evaluate the performance of a familiar device by
– identifying basic principles governing its operation and use
– inferring potential malfunctions and appropriate maintenance/repair procedures
– suggesting ways to improve efficiency of design and/or operation
• design and construct a simple technological device or process by
– identifying a relevant need or problem not satisfied by technology
– identifying alternative approaches/designs to deal with the problem
– selecting a design and constructing the device
– testing and troubleshooting the device
• infer how specific technologies have personal application and solve practical problems.</td></tr>
<tr><td>CONCEPTS</td><td>Students will be expected to demonstrate an understanding that:
• technology is the process of using scientific knowledge to solve practical problems
• basic scientific principles are associated with the functioning of technological devices
• many technological systems consist of combinations of sub-systems that work together in accomplishing a particular task
• science can be used to advance technology and technology can be used to advance science
• new and emerging technological products/processes reflect current needs and wants in society
• products of technology are often used by society before the full extent of benefits/problems resulting from their use can be known.</td><td>Students will be expected to demonstrate an understanding that:
• the automobile is a technological system consisting of a number of subsystems that work together
• basic scientific principles are associated with the functioning of sub-systems in an automobile
• simple maintenance procedures contribute to the efficient performance and general safety of an automobile
• the nature of injuries sustained in an automobile accident can be anticipated by considering the effects of first and second collisions
• technology has contributed to safe travel through the development of highway/automobile safety features
• political, ethical and economic perspectives often interact with science and technology in making decisions that advance safe travel.</td></tr>
</table>

UNDERSTANDING OUR ENVIRONMENT

<table>
<tr><th></th><th>SCIENCE 16
MANAGING ENVIRONMENT AND RESOURCES</th><th>SCIENCE 26
ENERGY AND THE ENVIRONMENT</th></tr>
<tr><td>ATTITUDES</td><td colspan="2">Students will be encouraged to:
• display a positive attitude toward the learning of concepts and skills in science
• appreciate the fragility of the biosphere
• appreciate the interdependence of self with other living forms and the environment
• appreciate that environmental issues involve significant relationships among science, technology and society
• realize our inability to anticipate the environmental effects of human activities
• appreciate that the collective action of individuals can have significant impact
• develop a sense of personal responsibility in relation to environmental issues.</td></tr>
<tr><td>SKILLS</td><td colspan="2">Students will be expected to demonstrate an ability to:
• identify an environmental issue related to the local use of natural resources
• gather information related to the issue through observation, interview and/or research
• design experiments, through class discussion, that illustrate how particular practices or products are related to the issue, and influence environmental quality
• analyze and assess information by identifying patterns and relationships, by judging the reliability/validity of information gathered and by considering consequences
• communicate the results of investigation verbally, through the use of models and diagrams, and/or through written expression
• take an informed position on the issue, identifying strategies that may be used to deal with the situation.</td></tr>
<tr><td>CONCEPTS</td><td>Students will be expected to demonstrate an understanding that:
• the biosphere is a thin layer on the surface of the earth, able to support life
• a continuous supply of solar energy is essential to life
• life depends upon recycling processes
• living organisms interact with each other and with the physical environment
• individuals and society influence the quality of the environment
• developments in science and technology may have unforeseen consequences on society and the environment
• individuals and society can become involved in the resolution of ecological problems that arise.</td><td>Students will be expected to demonstrate an understanding that:
• a variety of different forms of energy are used at home and at work
• there are renewable and non-renewable sources of energy
• energy systems have input, conversion and output components
• the total energy of a system is conserved
• energy efficiency ratings describe the portion of input energy that is converted to useful energy
• personal energy consumption can be analyzed and monitored
• energy conservation involves the interaction of economic, political and ethical perspectives with science and technology.</td></tr>
</table>

LEARNING RESOURCES FOR SCIENCE 16

STUDENT RESOURCES

BASIC LEARNING RESOURCES

The learning resources listed below address the majority of the goals and learning objectives identified in this *Program of Studies/Curriculum Guide*. Because of the modular format of the learning resources, they have been listed separately for each theme within the science program.

Theme A: Systems of the Human Body

Hutton, Glen, ed. *Your Body in Balance*. ISIS Individualized Science Instructional System (Booklet). Revised. Scarborough, Ontario: Globe/Modern Curriculum Press, 1989.

Theme B: Chemistry for the Consumer

Hutton, Glen, ed. *Household Science*. ISIS Individualized Science Instructional System (Booklet). Revised. Scarborough, Ontario: Globe/Modern Curriculum Press, 1989.

Theme C: Using Systems and Technologies

Hutton, Glen, ed. *Science, Technology, and You*. ISIS Individualized Science Instructional System (Booklet). Revised. Scarborough, Ontario: Globe/Modern Curriculum Press, 1989.

Theme D: Managing Environment and Resources

Hutton, Glen, ed. *Investigating the Environment*. ISIS Individualized Science Instructional System (Booklet). Revised. Scarborough, Ontario: Globe/Modern Curriculum Press, 1989.

SUPPORT LEARNING RESOURCES

The learning resources listed below assist in addressing some of the learning objectives identified in this *Program of Studies/Curriculum Guide*. Because of the modular format of the learning resources, they have been listed separately for each theme. Multiple copies (but not necessarily class sets) of each resource may be desired.

Theme A: Systems of the Human Body

Mooney, Libby and Andy Rivers. *Body Maintenance*. Science at Work Series, Third Edition (Booklet). Harlow, England: Longman Group Limited, 1989.

Theme B: Chemistry for the Consumer

Wilshaw, Chris and Paul Wright. *Cosmetics*. Science at Work Series, Third Edition (Booklet). Harlow, England: Longman Group Limited, 1989.

Theme C: Using Systems and Technologies

Taylor, John. *Gears and Gearing.* Science at Work Series (Booklet). Harlow, England: Longman Group Limited, 1985 (new edition pending).

Theme D: Managing Environment and Resources

Rowlands, David. *Pollution.* Science at Work Series, Third Edition (Booklet). Harlow, England: Longman Group Limited, 1989.

OTHER LEARNING RESOURCES

Other learning resources that may be useful in implementing the Science 16 program are identified below. These resources have not been evaluated by Alberta Education, and their listing is not to be construed as an explicit or implicit departmental approval for use. These titles are provided as a service only, to assist local jurisdictions in identifying potentially useful learning resources. The responsibility for evaluating these resources prior to selection rests with the local jurisdiction.

Heimler, Charles. *Principles of Science, Book 1.* Columbus, Ohio: Charles E. Merrill Publishing Company, 1986.

Heimler, Charles. *Principles of Science, Book 2.* Columbus, Ohio: Charles E. Merrill Publishing Company, 1986.

Mardall, O. J. et al. *Science Networks: Biology.* Toronto, Ontario: Globe/Modern Curriculum Press, 1982.

Mardall, O. J. et al. *Science Networks: Physical Science.* Toronto, Ontario: Globe/Modern Curriculum Press, 1983.

Robertson, Alan. *Choices for Health.* Scarborough, Ontario: Nelson Canada, A Division of International Thomson Limited, 1983.

Taylor, John (Project Director). *Science at Work Series.* Harlow, England: Longman Group Limited.

Booklets: *Electronics* (1989)
Food and Microbes (1987, revised edition pending)
Photography (1989)
Telecommunications (1987)

Wilde, George. *Applied Science, Book 1.* Melbourne, Australia: Longman Cheshire Limited, 1986.

Wilde, George. *Applied Science, Book 2.* Melbourne, Australia: Longman Cheshire Limited, 1989.

TEACHER RESOURCES

The teacher guide listed below is designed to assist classroom teachers in using the basic learning resource.

Hutton, Glen. *ISIS Individualized Science Instructional System Teacher Resource Guide*. Revised. Scarborough, Ontario: Globe/Modern Curriculum Press, 1989.

(An *Evaluation and Resource Package* is also available for each booklet within the ISIS Individualized Science Instructional System. Each package contains additional puzzles, research projects and assessment techniques that may be useful in addressing individual needs within the science classroom.)

Other teacher resources identified as useful in addressing major goals and learning objectives within the science program are listed below.

Aikenhead, Glen. *Science in Social Issues: Implications for Teaching*. Ottawa, Ontario: Supply and Services Canada, 1980.

Alberta Education. *Clarification of Statements Prohibiting the Use of Human Body Substances in the Alberta Science Curriculum*. Edmonton, Alberta: Alberta Education, 1988.

Alberta Education. *Learning Contexts for Junior High Science*. Edmonton, Alberta: Alberta Education, 1989.

Alberta Education. *STS Science Education: An Opportunity for Unifying the Goals of Science Education*. Edmonton, Alberta: Alberta Education, 1989.

Armour, Margaret-Ann, et al. *Hazardous Chemicals: Information and Disposal*. Edmonton, Alberta: University of Alberta, 1985.

Bisacre et al. (Editors). *The Illustrated Encyclopedia of Technology*. New York, New York: Marshall Cavendish Books Limited, 1984.

Durie, Bruce. *Visual Science* (Series). London, Ontario: MacDonald Educational, 1987.

Liem, Tik L. *Invitations to Science Inquiry, Second Edition*. Lexington, Massachusetts: Ginn Custom Publishing, 1987.

Science Education Consultants. *Evaluation of Student Progress, A Workshop Manual for Administrators and Teachers*. Edmonton, Alberta: Alberta Education, 1985.

Science Education Consultants. *Safety and Organization in School Science Facilities, Second Edition*. Edmonton, Alberta: Alberta Education, 1986.

Science Education Consultants. *WHMIS: Abridged Guidelines for Schools*. Edmonton, Alberta: Alberta Education, 1989.

TECHNOLOGY AND MEDIA

There is a growing collection of technology and media materials (e.g., films, videos, computer software, kits, pamphlets) that may support the development of specific learning objectives within the science program. Some potential resources of this nature have been identified below. Teachers are encouraged to contact local media services, libraries and government agencies in obtaining these and/or other materials considered appropriate to the science program.

OTHER LEARNING RESOURCES

Video Programs

The video programs listed below may assist in addressing some of the learning objectives identified in the *Program of Studies/Curriculum Guide*. Their listing is not to be construed as an explicit or implicit departmental approval for use. Titles are provided as a service only to assist local jurisdictions in identifying potentially useful learning resources. The responsibility for evaluating each resource prior to selection rests with the local jurisdiction.

Acme School of Stuff (Series). TV Ontario, 1988.
Chemistry in Everyday Life. Britannica, 1987.
Farewell, Ancient Mariner. Canadian Filmmakers.
Greenhouse Effect. Canadian Broadcasting Corporation, 1984.
The Human Body Series. National Geographic, 1988.
The Problem-Solving Film. Omega, 1988.
Science Edition II. TV Ontario, 1987.
The Scientific Method. VEC, 1987.
Simple Machines. Kinetic Incorporated, 1988.

These programs are available through ACCESS NETWORK and/or Regional Resource Libraries. A description of each program is provided in Appendix A.

Computer Software

An annotated list of computer software that may be useful in implementing the Science 16 program is provided in Alberta Education's catalogue of *Computer Courseware Evaluations* (Curriculum Support Branch, Student Programs and Evaluation Division, Alberta Education, 1986) and annual supplements.

Government Agencies

Local, provincial and federal government agencies are often able to provide information relevant to learning objectives within the science program. Provincial government agencies that may provide resource materials appropriate to particular themes in Science 16 include:

Alberta Alcohol and Drug Abuse Commission (AADAC)
Alberta Consumer and Corporate Affairs
Alberta Economic Development and Trade
Alberta Energy
Alberta Technology, Research and Telecommunications
Alberta Transportation and Utilities
Environment Council of Alberta.

Information that will assist teachers in contacting these government agencies is provided in Appendix B.

ACCESS NETWORK

ACCESS offers a variety of resources and services to teachers. For a nominal dubbing and tape fee, teachers may have ACCESS audio and video library tapes copied. ACCESS also offers a service called "Night Owl Dubbing". This allows educators to tape late night educational programs directly from their own televisions.

ACCESS publishes both an *Audio-Visual Catalogue* and a comprehensive schedule of programming, available on request.

For additional information, contact ACCESS NETWORK, Media Resource Centre, 295 Midpark Way SE, Calgary, Alberta, T2X 2A8 (from outside of Calgary, telephone toll free, 1-800-352-8293; in Calgary, telephone 256-1100).

REGIONAL RESOURCE LIBRARIES

Films and videos are available for loan through the five centres listed below. In some instances, computer software is also loaned. Catalogues of holdings are available upon request.

Zone I

Zone One Regional Film Centre
P.O. Box 6536 / 10020 – 101 Street
Peace River, Alberta
T8S 1S3
Telephone: 624-3187

Zone II and III

Central Alberta Media Service (CAMS)
2017 Brentwood Boulevard
Sherwood Park, Alberta
T8A 0X2
Telephone: 464-5540 / 467-8896

Zone IV

Alberta Central Regional Education Services (ACRES)
County of Lacombe No. 14
Box 3220 / 5140 – 49 Street
Lacombe, Alberta
T0C 1S0
Telephone: 782-5730

Zone V

South Central Alberta Film Federation (SCAFF)
Westmount School
Box 90 / Wheatland Trail
Strathmore, Alberta
T0J 2H0
Telephone: 934-5028

Zone VI

Southern Alberta Regional Film Centre (SCARFC)
c/o McNally School
P.O. Box 845
Lethbridge, Alberta
T1J 3Z8
Telephone: 320-7807

CORRELATION OF BASIC LEARNING RESOURCES TO SCIENCE 16

A correlation of four booklets within the ISIS Individualized Science Instructional System to themes identified for Science 16 is provided below. The correlation chart illustrates how the booklets can be used to address prescribed learning objectives within each theme of the science program.

SCIENCE 16 THEMES

	Systems of the Human Body	Chemistry for the Consumer	Using Systems and Technologies	Managing Environment and Resources
ISIS BOOKLET: ***YOUR BODY IN BALANCE***				
1. Your Internal Transportation System	p. 5			
2. Science, Technology and Your Heart	p. 13			
3. Adventures of a Sandwich	p. 22			
4. Sensing Your Environment	–			
5. All Systems Are So	p. 38			
6. Balanced Systems and Technology	p. 45			
7. Blood's Balancing Act	p. 54			
8. Endocrine Glands and Your Digestive System	p. 63			
9. A Tree, a Paramecium and You	–			
10. An Earthworm and You	–			
11. A Frog and You	–			
ISIS BOOKLET: ***HOUSEHOLD SCIENCE***				
1. Home Sweet Science		p. 5		
2. How Much and How Many		p. 9		
3. Water Doesn't Act Like Milk		p. 15		
4. Acids and Bases		p. 23		
5. Heat and Household Reactions		p. 31		
6. Heat Flow, Gelatin and Soup		p. 39		
7. Heat Flow, Conservation and Safety		p. 45		
8. Solutions Don't Act Like Pure Substances		p. 51		
9. Hot and Cold Solutions		p. 58		
10. Candy and Crystals		p. 64		
11. Popcorn and Other Suspensions		p. 70		
12. Safe at Home		p. 76		

SCIENCE 16 THEMES

	Systems of the Human Body	Chemistry for the Consumer	Using Systems and Technologies	Managing Environment and Resources
ISIS BOOKLET: *SCIENCE, TECHNOLOGY AND YOU*				
1. Technology and Society's Needs and Wants			p. 5	
2. Science, Technology and Your Five Senses			p. 12	
3. The Scientific Process and Simple Machines			p. 17	
4. The Scientific Process and Electricity			p. 25	
5. Current Electricity, Servant of Technology			p. 30	
6. Sound and Ways Science Advances Technology			–	
7. Telephone Transmitter Technology			–	
8. Magnets, Electromagnets and Telephone Receivers			–	
9. Telecommunications – Advantages and Disadvantages			p. 60	
ISIS BOOKLET: *INVESTIGATING THE ENVIRONMENT*				
1. Telephones and Trash				p. 5
2. Environments and Values				p. 12
3. Meet the Biosphere				p. 18
4. Sun Energy – Who Needs It				p. 27
5. Food Webs, Pyramids and Energy				p. 36
6. Cycles and Recycling				p. 46
7. Ecosystems and Populations				p. 54
8. Environments – For Better or for Worse				p. 61

SAFETY IN THE SCIENCE CLASSROOM

Safety must be a major consideration as students become actively involved in experimental procedures and laboratory settings. An awareness of safety should be developed through a common sense approach. Students should recognize that specific hazards can be avoided through advance planning and an awareness of hazardous materials and situations. No laboratory work should be expected of students if they are not fully aware of possible hazards and preventative measures.

When conducting experiments and investigations, students will be expected to display a concern for safety by:

- following directions exactly as given
- understanding the import of what they are doing
- maintaining order and neatness when using equipment
- using prior knowledge to make judgments
- asking for advice when in doubt.

Students should be encouraged to transfer the safety knowledge and attitudes developed in school to potentially dangerous situations they may encounter at home, at work and in the community.

RESPONSIBILITIES OF THE TEACHER

Teachers must provide adequate supervision of students at all times, and emphasize accident prevention. Students must be alerted to situations they may create that are unsafe or hazardous.

The most effective method of teaching safety is by example. The procedures and attitudes modelled by the teacher influence students more than actually teaching a unit on safety. The teacher must be conscious of the example being set and, through modelling, assist students to develop appropriate safety habits and attitudes, including:

- careful observation and alertness at all times
- application of safety procedures and techniques
- advance identification of safety responsibilities associated with experimental procedures that are planned.

RESPONSIBILITIES OF THE STUDENT

Students must be alerted to general safety precautions and procedures early in the science program. Specific hazards and precautions related to the use of equipment and chemicals must be discussed as the materials are used. Students should learn to plan their laboratory investigations and procedures in ways that will minimize the possibility of accidents. All accidents and unexpected events that occur should be reported and discussed with the teacher.

It is advised that a **Student Safety Contract** be issued early in the school year, after students have been alerted to general safety precautions and procedures. Use of a safety contract will increase the students' awareness of personal responsibilities in the safety of self and others. A sample student safety contract is provided on the following page.

STUDENT SAFETY CONTRACT

I will:

- Follow all safety instructions given by the teacher.
- Protect eyes, face, hands and body while conducting class activities.
- Carry out good housekeeping practices.
- Be able to locate first-aid and firefighting equipment
- Conduct myself in a responsible manner at all times in a laboratory situation.

I, ______________________________, have read and agree to abide by the safety regulations as set forth above and any additional verbal and printed instructions provided by the teacher and/or school.

Date ____________________________ ______________________________

Signature

SAFETY GUIDELINES AND POLICIES

Teachers must be familiar with safety policies and statements adopted by their employing board. In the absence of such statements, teachers should be aware of specific hazards that students face in the science program and take suitable precautions to avoid such hazards.

Teachers must also be familiar with policy and information provided in Alberta Education's monograph *Clarification of Statements Prohibiting the Use of Human Body Substances in the Alberta Science Curriculum*, 1988. (Due to the potential risk of infection from hepatitis and AIDS, all activities involving the extraction and analysis of samples of human fluid or tissue are prohibited in Alberta schools.)

Additional safety information is provided in:

- *Safety and Organization in School Science Facilities*, a resource book for elementary and secondary schools by Science Education Consultants, Alberta Education, 1988.
- *Hazardous Chemicals: Information and Disposal*, a resource by Margaret-Ann Armour, Lois Browne and Gordon Weir. Published by the University of Alberta, Edmonton, 1985.

While no set of safety rules can be complete, the suggestions that follow may provide direction in establishing a set of appropriate safety procedures for the science program.

e.g., – Never leave students unsupervised.
– Insist upon the use of correct laboratory techniques.
– Strictly enforce rules with regard to behaviour.
– Avoid any laboratory procedure if there is any doubt as to its safety.

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- Locate and teach the use of appropriate safety equipment (e.g., eyewash, first-aid kit, fire blanket, fire extinguisher).
- Provide medical attention immediately if there is any question as to its need.
- Insist that students carry out a procedure only after they understand how it is to be done.
- Ensure that students are properly dressed (e.g., wearing protective glasses or aprons if required; no loose clothing or hair that will interfere with equipment and materials).
- Provide instruction in appropriate procedures for using possibly hazardous equipment and supplies such as bunsen burners, alcohol lamps, candles, acids/bases or solvents.
- Provide adequate ventilation, working space and suitable equipment for each investigation.
- Label all chemicals clearly.
- Store potentially dangerous chemicals and apparatus in a locked and well-organized storeroom.
- Insist on well-planned and organized procedures, and on cleanliness of hands, benches, tables and equipment.
- Do not allow students to use concentrated acids or bases, volatile solvents, sodium, potassium, phosphorus or hydrogen.
- Do not heat anything in glass other than pyrex.
- Do not heat test tubes over an open flame.
- Use 110 volt electricity only in CSA approved apparatus.
- Do not force glass tubing through rubber stoppers.
- Do not allow activities that involve the extraction or analysis of human tissue or fluid (e.g., cell scrapings, blood samples).

WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM

The Workplace Hazardous Materials Information System (WHMIS) is a hazard communications program designed to protect workers across Canada from injuries and illnesses caused by exposure to chemicals. The program uses federal and provincial legislation to ensure:

- the labelling of hazardous materials
- the provision of material safety data sheets (MSD's) by suppliers of hazardous materials
- worker education/instruction programs.

WHMIS provides a way for teachers to obtain information about hazardous materials that may be used in the science program. Science teachers should consult WHMIS in order to identify the hazards of various materials and the precautions to take when using these materials. Additionally, all secondary school students should receive instruction about WHMIS, and use the system in their work. WHMIS instruction is probably of greatest value at opportune times before and during students' use of controlled products, rather than as an individual topic of study.

Policy and information on WHMIS is provided in *WHMIS: Abridged Guidelines for Schools,* a resource booklet prepared by the Science Education Consultants' Council, Alberta Education, 1989. Posters, booklets and pamphlets that describe features of WHMIS are available at no cost from the nearest Regional Office of Alberta Occupational Health and Safety.

Other resource materials on WHMIS include a videotape *WHMIS: Working for You* and a reference manual *WHMIS Core Material: A Resource Manual for the Application and Implementation of WHMIS (1989 Revised Edition).* These materials can be ordered through the Alberta Association of Safety Personnel/Canadian Society of Safety Engineers Provincial Body at the address provided below.

AASP/CSSE Provincial Body
P.O. Box 262, Main Post Office
Edmonton, Alberta
T5J 2J1

EQUIPMENT AND MATERIALS

An activity-based science program requires pre-planning and the gathering of equipment and materials. Assuming a standard science laboratory with basic equipment, the materials required for Science 16 are for the most part simple, inexpensive and easily obtained. Each investigation suggested within the student learning resources provides a list of materials that are required in order to conduct the activity.

The guidelines that follow are intended to assist teachers when planning for equipment and materials needs within each theme of the science program.

- When obtaining materials, ensure that quantities are sufficient for small group work, thus facilitating maximum student participation.
- A "scrounging list" taken home by students may produce much of the needed equipment and materials. Some items collected from home may be used "as is", and others may be reconstructed as substitutes for more expensive laboratory equipment. The processes of improvision and construction can provide valuable learning experiences for students as they practise basic skills and techniques, and see the results of their endeavours in the equipment they use.
- Some equipment and materials relevant to the science program may also be used in occupational courses. Consider a loan of these items for demonstrations and/or related activities.
- A petty cash system set up at the school will facilitate the purchase of inexpensive and disposable items that may be obtained from the local hardware, drug store or supermarket. (e.g., Most of the chemicals used in the science program are common household substances and need not be of a special laboratory grade.)
- If making a major purchase of equipment or materials, consult local wholesalers and distributors for better buys than may be available through scientific supply companies.

Teachers should recognize that they may not require every item listed throughout the learning resources, and that equipment/material needs will be determined by the activities they select throughout the science program.

INTERPERSONAL SKILLS AND COOPERATIVE LEARNING

Many science activities provide opportunities for students to develop strategies and skills by working in cooperative learning situations. Group work often provides students with a less threatening environment, where they may be more willing to take the risks associated with inquiry, problem solving and decision making. Students participating in group activities can learn new strategies from others, and refine their own processing skills.

Skills best learned in group settings may include the ability to:

- clarify one's own ideas
- consider alternative ideas and approaches
- compare and assess alternatives.

CLARIFICATION/EXAMPLE

A Paired Problem-Solving Strategy[1]

Students are divided into pairs (problem solver, recorder) in order to work together in solving a problem. The use of a "thinking-aloud" procedure allows the student to see how their partner thinks and solves problems. Thinking steps are thus open to view and can be observed and communicated. The procedure used is:

1. One member (the problem solver) "thinks aloud" while solving a given problem.
2. The other member (the recorder) listens carefully, noting the steps taken in the solving of the problem. At the end of this "think aloud" procedure, the recorder may ask clarification questions of the problem solver and/or may point out errors made in the problem-solving process.
3. Roles are reversed, repeating the same problem.
4. The modification/extension of both strategies are discussed with each person (or both if agreement is reached) documenting the best "modified" strategy.

This strategy could be expanded to include three people by subdividing the recorder's role into recorder and questioner. The three roles would rotate.

Interpersonal skills can also be enhanced through cooperative learning experiences. As students work in group settings, problems in social interaction may arise. A strategy for systematically analyzing a social problem is provided on the next page. This strategy helps students to identify:

- reasons for the difficulty/conflict
- strategies that may avoid the difficulty/conflict another time.

Teacher modelling and student use of this strategy may enable students to gain confidence in their ability to interact effectively and communicate with one another.

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[1] Adapted from *SPELT: A Strategies Programme for Effective Learning/Thinking: Inservice Edition*, SPELT International, Ltd., p. 197. Copyright 1987 by R. Mulcahy, K. Marfo, D. Peat and J. Andrews. Reprinted by permission.

SPOT (SOCIAL PROBLEM-SOLVING STRATEGY)

Description of Strategy

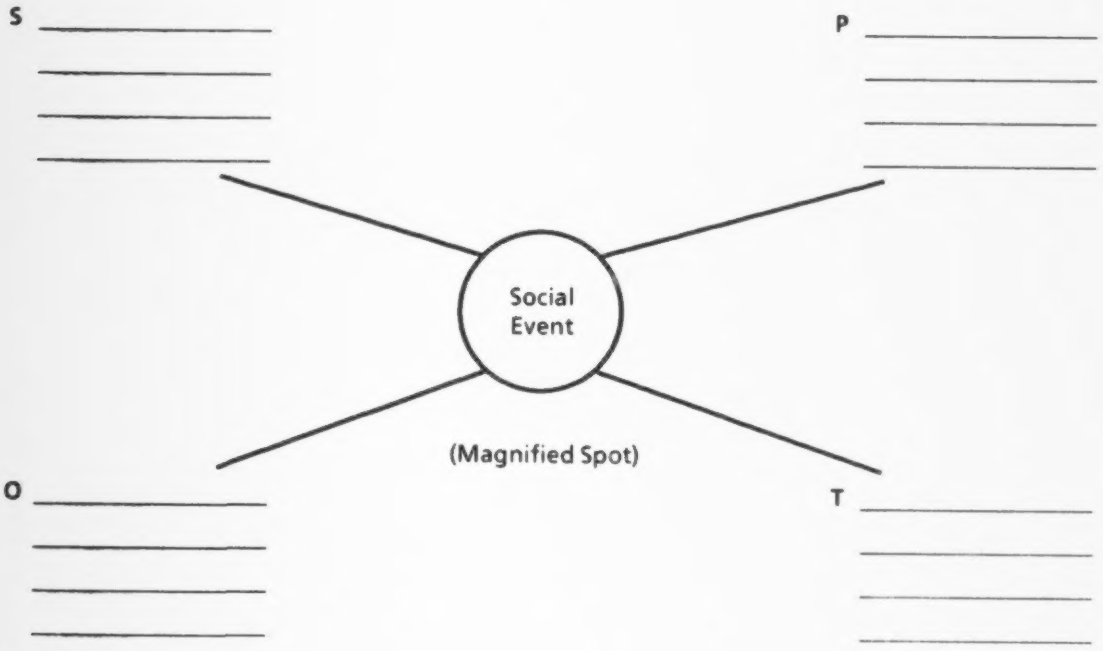
S: Setting: Who? What? Where? When?

P: Problem: What's the situation to be solved?

O: Order of action: What happened?

T: Tail End: What can be done next time?

Problem-Solving Chart:



From *Strategies for Teaching Students with Learning and Behaviour Problems* by Dr. C. Boss, and S. Baughn. Copyright 1988 by Boston, Allyn and Bacon. Reprinted by permission.

THEME A
SYSTEMS OF THE HUMAN BODY

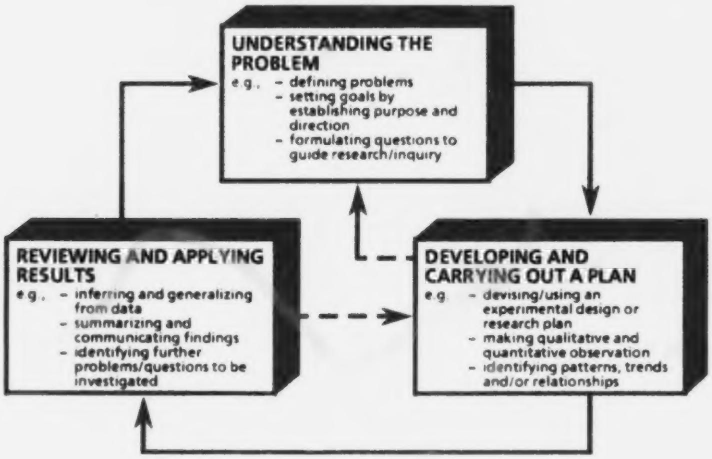
Life functions are performed by a number of body systems interacting with one another and the environment. An understanding of these body systems and various factors that may affect their functioning will assist individuals to acquire and maintain healthy lifestyles. This theme will provide opportunities for students to:

- examine critical life functions and the body systems that perform these functions
- recognize interrelationships that exist among nutrition, level of fitness and personal health factors
- identify appropriate strategies for acquiring and maintaining personal health.

Particular attention should be placed on developing strategies for gathering information through research and experiment. A focus on the nature of science and the inquiry process will enable students to understand the way in which knowledge of human body systems is gathered, as well as use appropriate processes to conduct investigations of their own. Teachers are encouraged to reference the "Program Emphases and Methodology" section of this manual when planning for instruction. Suggestions particularly relevant to the learning objectives addressed in this theme can be found in:

- Nature of Science.
- Communication Skills.
- Assessment/Evaluation.

A FRAMEWORK FOR INVESTIGATING HUMAN BODY SYSTEMS


UNDERSTANDING THE PROBLEM
e.g., – defining problems
– setting goals by establishing purpose and direction
– formulating questions to guide research/inquiry
DEVELOPING AND CARRYING OUT A PLAN
e.g. – devising/using an experimental design or research plan
– making qualitative and quantitative observation
– identifying patterns, trends and/or relationships
REVIEWING AND APPLYING RESULTS
e.g., – inferring and generalizing from data
– summarizing and communicating findings
– identifying further problems/questions to be investigated

CONCEPTS, SKILLS AND ATTITUDES

CONCEPTS

Students will be expected to demonstrate an understanding that:

- the human body system is the product of a number of body systems working together to perform critical life functions
  - identifies critical life functions and the body systems that perform them
  - describes how each system contributes to the health of the individual
- each body system has specific structures that enable it to perform a critical life function
  - identifies individual structures within the digestive and circulatory systems
  - describes the functions associated with individual structures that are identified
- functional relationships among systems of the human body are critical to life
  - illustrates, through example, how a body system adjusts to changes in other body systems in order to maintain balance (e.g., blood sugar, breathing and heart rate)
  - illustrates through example, what happens when disturbances occur in one body system and other systems are unable to adjust (e.g., stroke, heart attack)
- medical technology can be used to monitor body conditions and personal health factors
  - gives examples of ways in which technology can be used to monitor critical life functions
  - describes how technology may assist in diagnosing/treating malfunctions within body systems
  - illustrates, through example, how science and technology work together to expand our knowledge of body systems
- interrelationships exist between nutrition, level of fitness and personal health
  - explains how lifestyle factors and decisions may affect personal health
  - identifies strategies for maintaining personal health through diet and physical exercise
  - infers the consequences of improper diet, weight and exercise on personal health
- societal issues may arise from the use of technologies in preserving balance among systems of the human body
  - describes how technologies can be used to preserve the balance of life when one or more systems are in failure (e.g., organ transplants, life support systems)
  - identifies societal issues that arise when technologies are used to reserve balance when a system is in temporary or permanent failure.

SKILLS

Students will be expected to demonstrate an ability to:

- collect data related to critical life functions and body systems through observation, interview and/or research
- design an experiment, through class discussion, that illustrates the use of a technology (e.g., stethoscope) in monitoring variations in the functioning of a body system
- use selected monitoring technologies in collecting data about personal health and fitness factors
- analyze and assess personal health and fitness factors by identifying relationships, by considering consequences, and by examining a variety of viewpoints
- infer potential threats to personal health that may be caused by lifestyle factors (e.g., diet, level of activity)
- apply the results of investigation to personal situation, identifying appropriate strategies for monitoring and maintaining personal health.

ATTITUDES

Students will be encouraged to:

- display a positive attitude toward the learning of concepts and skills in science
    - shows interest and curiosity through willingness to ask questions, share observations and ideas, and seek answers
    - performs investigations and completes assignments independently and in cooperation with others
- appreciate the intricate workings and balance within the human body
- appreciate the contributions of science and technology to human health
- value knowledge gained for its usefulness on a personal level
- appreciate the need for informed decision making at both personal and societal levels
- appreciate that ethical dilemmas may arise from the application of scientific research and/or medical technologies
- display responsible attitudes toward personal health through nutrition, exercise, safety and lifestyle.

INTEGRATION ACTIVITIES

ENGLISH

Students will use a variety of communication skills throughout investigations that are undertaken in this theme. Instructional activities will require students to:

- use comprehension skills when gathering information related to human body systems and personal health factors
- give and follow directions when devising and/or using an experimental design or research plan
- use viewing/reporting/note-taking skills when gathering, organizing and communicating data obtained through research and experimentation.

Teachers are encouraged to identify appropriate strategies for developing these skills through cooperative conferencing with English teachers. Suggestions and ideas for developing related skills are also provided in the "Communication Skills" section of this manual.

MATHEMATICS

Students will use mathematical concepts and skills when they:

- measure mass, distance, capacity and time
- interpret statistical data involving ratio and percent
- interpret measures of central tendency
- interpret and display data in table/chart/graph form.

Science teachers are encouraged to confer with mathematics teachers in establishing relevant contexts and appropriate methodology for reinforcing the mathematical competencies that students will use throughout this theme. Teachers can plan activities that will enable students to use mathematics class to interpret and display the data they gather through experiments performed in science.

SOCIAL STUDIES

Students will develop an awareness of the effects of environmental and lifestyle factors on human body systems and personal health factors through activities in current affairs. Cooperative planning between the science and social studies teachers may provide opportunities for students to investigate:

- recent contributions of science and technology to the diagnosis and treatment of malfunctions in human body systems
- social costs related to technological advancements in the fields of medicine and health care.

The study of community and provincial service systems in social studies will enable students to develop strategies for accessing medical assistance and advice.

OCCUPATIONAL COURSES

Students will develop an awareness of how personal health and lifestyle factors may influence:

- employment opportunities
- job performance, attendance and retention.

Both science and occupational teachers should emphasize the negative effects of substance abuse on human body systems, personal health and safety, work performance and job retention.

COMMUNITY PARTNERSHIP OPPORTUNITIES

The local community may offer a variety of resources that contribute to the development of learning objectives within this theme. Suggestions for using these resources, and for developing strategies for monitoring and maintaining personal health through situational and concrete learning experiences in the community are provided below.

- Invite the school nurse to demonstrate the use of various technologies and procedures in collecting data about personal health and fitness factors (e.g., blood pressure, pulse rate, body heat, heartbeat recovery rate).
- Invite a first-aid specialist to demonstrate and explain various ways of rendering emergent help to persons who are critically injured (e.g., giving assistance to someone in shock or someone who is choking; helping someone to breathe; helping someone who has a broken limb).
- Invite a doctor (or nurse) to discuss the relationship between nutrition, fitness and lifestyle. Ask this person to outline special nutritional needs of adolescents and young adults.
- Invite a representative from the Alberta Alcohol and Drug Abuse Commission (AADAC) to speak to the class about the effects of alcohol, drugs and tobacco on systems of the human body.
- Invite medical experts/police officers/social workers/rehabilitated clients to discuss the effects of substance abuse on human body systems and the functions they perform.
- Invite a nutritionist to discuss the facts, fads and fallacies of eating habits and diets.
- Invite a public health worker to discuss immunization practices.
- Invite a pharmacist to discuss:
  - differences between prescription and non-prescription drugs
  - the effects of different types of drugs on human body systems
  - the importance of following directions/dosages provided on the labels of prescription and non-prescription drugs
  - strategies for practising drug safety in the home
- Invite a local fitness expert to discuss:
  - personal fitness measures
  - strategies for maintaining/improving endurance, strength and flexibility
  - nutritional needs of athletes in training
- Invite a health care specialist to discuss contributions of science and technology in health care, disease prevention and the extension of human life (e.g., heart pacemakers, artificial organs, medicine/drugs, immunization).
- Obtain various media resources on monitoring and maintaining personal health (e.g., pamphlets, films, videos) by contacting local and provincial health service systems.

RESOURCE CORRELATION

BASIC RESOURCE

ISIS Individualized Science Instructional System
Booklet: *Your Body in Balance*

SUPPORT RESOURCES

Science at Work Series
Booklet: *Body Maintenance*

OTHER RESOURCES

Applied Science, Book 1
Unit 19 – Using Food

Applied Science, Book 2
Unit 11 – The Skeleton: Our Bony Frame
Unit 12 – The Beat of a Lifetime
Unit 13 – The Nervous System
Unit 14 – Coordination Chemistry: Our Endocrine System
Unit 16 – The Breath of Life: Our Respiratory System
Unit 17 – The Excretory System

Choices for Health
Chapter 1 – Your Body Structures
Chapter 2 – Fueling Your Body
Chapter 3 – Your Body Controls

The Human Body Series (video program)

Principles of Science, Book 2
Chapter 2 – The Human Body
Chapter 3 – Circulatory Systems
Chapter 4 – Internal Body Processes
Chapter 5 – Nervous and Endocrine Systems

Science Education II (video program)

Science Networks: Biology
Unit 3 – Digestive System
Unit 4 – The Circulatory System
Unit 5 – The Breathing System

SUGGESTED ACTIVITIES

The student learning resources identified above provide a variety of instructional activities that support learning objectives identified in this theme. The activities that follow complement those provided in the student learning resources. Teachers should be selective in their use, and consider students' interests/abilities and preferred methods of learning in planning appropriate instructional activities.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING THAT THE HUMAN BODY IS THE PRODUCT OF A NUMBER OF BODY SYSTEMS WORKING TOGETHER TO PERFORM CRITICAL LIFE FUNCTIONS.

- **Identifies critical life functions and the body systems that perform them.**
- **Describes how each system contributes to the health of the individual.**

RESOURCE CORRELATION

BASIC RESOURCE

Your Body in Balance
Chapter 5 – All Systems Are Go

SUPPORT RESOURCE

Body Maintenance
Chapter 1 - Reacting to Changes

1. Compare and contrast the functioning of body systems to the functioning of major systems in an automobile. Use this analogy to illustrate:
   - how each system has a particular task/function to perform
   - how individual parts and systems work together in performing essential life functions.
2. Assist students to understand how each system of the human body contributes to the health of an individual by considering the consequences of dysfunctions within individual body systems.

   e.g.,
   - the removal of a body organ
   - high blood pressure
   - a hemorrhage
   - paralysis
   - respiratory disease
3. Invite a local medical expert (e.g., doctor, nurse) to explain:
   - critical life functions that are performed by systems of the human body
   - how lifestyle factors (e.g., diet, exercise) may influence the functioning of particular body systems.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING OF THE DIGESTIVE SYSTEM AND CIRCULATORY SYSTEM IN THE HUMAN BODY.

- **Identifies individual structures within each system.**
- **Describes the functions associated with each structure.**

RESOURCE CORRELATION

BASIC RESOURCE

Your Body in Balance
Chapter 1 – Your Internal Transportation System
Chapter 3 – Adventures of a Sandwich

SUPPORT RESOURCE

Body Maintenance
Chapter 4 – The Blood System

1. Investigate the location and appearance of individual structures within the digestive and circulatory systems through the use of models and diagrams. Ask students to prepare and label their own diagrams of these body systems.

2. Encourage students (individually or in groups) to research the digestive and circulatory systems through reading and viewing activities. Following these investigations, ask students to explain:

   - specific functions associated with individual structures of each system
   - how individual structures within each system work together in performing a critical life function.

   Structure research activities using suggestions provided in Communication Skills, "Reading and Viewing Science Materials".

3. Identify common dysfunctions of the digestive and circulatory systems.

e.g.,	digestive system	circulatory system
	– ulcers	– anemia
	– heartburn	– hemophilia
	– cavities	– heart attack
	– stomach upset	– high blood pressure

   Discuss lifestyle factors that may cause dysfunctions within these body systems (e.g., nutrition, level of fitness, substance abuse).

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING OF THE IMPORTANCE OF FUNCTIONAL RELATIONSHIPS AMONG SYSTEMS OF THE BODY.

- **Illustrates, through example, how a body system adjusts to changes in other body systems in order to maintain balance (e.g., blood sugar, breathing and heart rate).**
- **Illustrates, through example, what happens when disturbances occur in one body system and other systems are unable to adjust (e.g., stroke, heart attack).**

RESOURCE CORRELATION

BASIC RESOURCE

Your Body in Balance
Chapter 6 – Balanced Systems and Technology
Chapter 7 – Blood's Balancing Act
Chapter 8 – Endocrine Glands and Your Digestive System

1. Identify internal and external changes in body systems that sometimes occur in emergency situations.

   e.g.,
   - pulse rate
   - "heart-in-throat" feeling
   - clammy skin
   - sweaty palms
   - loss of colour in skin

   Investigate how stressful situations may cause these changes in the human body.

2. Identify and investigate principals that govern the operation of a home thermostat (see Science and Technology, Resource 6: What is a Technological System?). Compare and contrast this feedback system to the temperature control system in the human body.

   Use this analogy to investigate other feedback/control systems within the human body.

   e.g., – blood sugar
   – metabolic activity
   – dilation of pupils
   – breathing and heart rate
   – muscular movements
   – skin sensation

   Prepare diagrams/flow charts that explain the operation of one or more of these feedback systems.

3. Identify situations where serious illness or possibly death may occur because the human body cannot adjust to major disturbances in one or more of its systems. Research factors and events that may lead to these situations.

   e.g., – heart attack
   – stroke
   – cancer
   – emphysema
   – pneumonia
   – anemia
   – anorexia

   Structure research activities using suggestions provided in "Communication Skills", and encourage students to identify:

   - particular body systems within which the disturbance originates
   - the nature of the disturbance
   - effects of the disturbance on other systems of the human body
   - lifestyle and other factors that may cause the disturbance
   - recent advances in technology that may be useful in diagnosing/treating the disturbance.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING OF THE CONTRIBUTIONS OF MEDICAL TECHNOLOGY IN MONITORING BODY CONDITIONS.

- **Gives examples of ways in which technology can be used to monitor critical life functions.**
- **Describes how technology may assist in diagnosing/treating malfunctions within body systems.**
- **Illustrates, through example, how science and technology work together to expand our knowledge of body systems.**

RESOURCE CORRELATION

BASIC RESOURCE

Your Body in Balance
Chapter 2 – Science, Technology and Your Heart

SUPPORT RESOURCE

Body Maintenance
Chapter 3 – Body Temperature

1. Investigate the use of medical technologies in monitoring critical life functions (e.g., microscope, stethoscope, endoscope, blood-pressure gauge, X-rays and scanners, electrocardiogram).

   Obtain information about these monitoring technologies through library research, or by visiting a local hospital/medical laboratory.

   Invite a doctor or nurse to illustrate and explain:

   - differences between a normal and abnormal electrocardiogram
   - how X-rays can be used to detect various abnormalities (e.g., broken bones, lesions on a lung)
   - strategies for monitoring blood pressure and pulse rate.

2. Assist students to design an experiment in which they use a selected technology to monitor variations in the functioning of one of their body systems (e.g., stethoscope, blood-pressure gage). Suggestions for designing and conducting experiments are provided in Nature of Science, "Useful Strategies and Skills".

3. Identify and discuss contributions of science and technology to human health. Encourage students to recognize situations in which:

   - developments in science and technology increase our knowledge of body systems and ability to diagnose/treat illness
   - societal attitudes influence developments in medical science and technology.

   Sample activities that focus attention on interrelationships among science, technology and society are provided in Science, Technology and Societal Issues, "Resource 3: How Do Science, Technology and Society Affect Each Other?". These ideas may help students understand how science, technology and society work together to expand our medical knowledge and resolve health-related issues.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING OF INTERRELATIONSHIPS THAT EXIST AMONG NUTRITION, LEVEL OF FITNESS, PERSONAL HEALTH AND LIFESTYLE.

- **Explains how lifestyle factors and decisions may affect personal health.**
- **Identifies strategies for maintaining personal health through diet and physical exercise.**
- **Infers the consequences of improper diet, weight and exercise on personal health.**

RESOURCE CORRELATION

SUPPORT RESOURCES

Body Maintenance
Chapter 2 – Food and Energy
Chapter 4 – The Blood System

Teacher Resource Manual
Resource 1: Nutrition
Resource 2: Monitoring Your Diet
Resource 3: Body Mass Index
Resource 4: Heartbeat Recovery Rates

1. Identify nutrients that are essential for good health, as well as the functions performed by these nutrients in the human body (see Resource 1: Nutrition). Summarize the results of investigation in a chart similar to the one illustrated below.

CLARIFICATION/EXAMPLE

NUTRIENT	FUNCTION
carbohydrates	
fats	
proteins	

2. Invite a doctor/nurse/dietitian/home economist into the classroom. Ask this person to discuss the relationship between nutrition and personal health, and to describe the functions performed by various nutrients in the human body (e.g., carbohydrates, fats, proteins, vitamins, minerals, water).

3. Ask students to record the foods they eat over a period of several days, using the "Weekly Food Intake Chart" provided in Resource 2: Monitoring Your Diet. Assess personal eating habits by referring to the nutritional guidelines provided in Resource 1: Nutrition. (e.g., Do personal diets include minimum amounts of the major food groups identified in the Canada Food Guide?) Ask students to calculate their nutritional scores using the table also provided in Resource 2: Monitoring Your Diet.

4. Prompt students to consider reasons for monitoring the intake of foods high in cholesterol and saturated fats. Discuss the effect that foods containing unsaturated and polyunsaturated fats are believed to have on cholesterol levels in the body. Identify familiar foods containing saturated, unsaturated and polyunsaturated fats.

5. Ask students to compare their present body weight to the guidelines suggested in Resource 3: Body Mass Index.

   Through class discussion, formulate strategies that may be effective in acquiring/maintaining a healthy body weight. Identify personal factors that must be considered in balancing food intake with food requirements (e.g., basal metabolic rate, activity level).

6. Provide opportunities for students to devise and conduct experiments that will enable them to test their endurance. Compare personal results with accepted norms.

   Students might take a fitness pre-test, undertake a fitness routine, and evaluate fitness gains through post-test activities.

7. Investigate the pumping function of the heart through use of a stethoscope borrowed from the school nurse. Ask students to locate their pulse beats, and to tabulate pulse rates under varying emotional or physical conditions.

   A sample activity that requires students to graph the relationship between heartbeat recovery rate and resting time is provided in Resource 4: Heartbeat Recovery Rates.

   Teachers must be aware of recommended "exertion" limits with respect to blood pressure/pulse rate, and ensure that students do not exceed these limits in their investigations.

8. Invite a doctor, nurse or other knowledgeable person to discuss the relationship between diet, body weight, level of fitness and personal health. Identify and discuss various lifestyle factors that affect personal health and life span.

   Obtain copies of pamphlets/brochures on health and lifestyle by contacting local government and community agencies. Suggested pamphlets include:

   - *Do You Have a FANTASTIC Lifestyle?* (Canadian Cancer Society, 1986).
   - *Food Track: Nutrition by Design* (B. C. Dairy Foundation, 1988).
   - *Premium Foods for Teens* (Alberta Community and Occupational Health).

9. Ask students to write an informal essay entitled "My Personal Health and Lifestyle Plan". The essay should describe strategies for monitoring and maintaining personal health through appropriate diet and exercise. When formulating strategies, encourage students to consider personal factors such as:

   - lifestyle
   - nutritional requirements and food preferences
   - financial resources.

   Structure writing activities by using the suggestions provided in Communication Skills, "Summarizing, Evaluating and Communicating Ideas in Science".

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING OF ISSUES THAT MAY ARISE FROM THE USE OF TECHNOLOGIES IN PRESERVING BALANCE AMONG SYSTEMS OF THE HUMAN BODY.

- **Describes how technologies can be used to preserve the balance of life when one or more systems are in failure (e.g., organ transplants, life support systems).**
- **Identifies societal issues that arise when technologies are used to preserve balance when a system is in temporary or permanent failure.**

RESOURCE CORRELATION

SUPPORT RESOURCES

Body Maintenance
Chapter 5 – Damage and Repair

Teacher Resource Manual
Resource 5: What Issues Surround the use of Life Support Systems?

1. Research recent developments in technology that are used to preserve balance among systems of the human body.

   e.g., – organ transplants
   – artificial body parts
   – dialysis
   – colostomies
   – laser surgery

   Research activities should involve the use of a variety of current resources (e.g., periodicals, pamphlets, guest speakers, films, videos), and may require students to:

   - investigate and report on a recent organ transplant recipient
   - prepare a list of artificial body parts that have been implanted in humans (e.g., "Jarvik Heart")
   - prepare a diagram that illustrates how a particular life support system functions (e.g., kidney dialysis machine)
   - explain applications of laser surgery (e.g., dysfunctions of the human eye)
   - predict accomplishments in medical technology that may occur in the next 5, 10 or 15 years.

2. Discuss and debate ethical dilemmas that arise from the use of technology in preserving life when a system is in temporary or permanent failure. A sample activity that illustrates dilemmas that result from applications of science and technology in health and medicine is provided in Resource 5: What Issues Surround the Use of Life Support Systems?

   Structure discussion and debate using suggestions provided in Communication Skills, "Strategies for Discussing and Debating". Encourage students to explore a variety of alternatives and perspectives related to the issues investigated by using strategies provided in Communication Skills, "Using Critical Thinking Skills" (e.g., Plus-Minus-Interesting, Consider all Factors, Consequences and Sequels).

3. Provide opportunities for students to express their opinions on current health problems/issues through informal writing activities. Encourage students to:

   - elaborate on an opinion they hold with regard to a health problem/issue
   - provide detail that will support their opinion/point of view.

   Suggestions for structuring and evaluating informal writing assignments are provided in Communication Skills, "Informal Essay Writing".

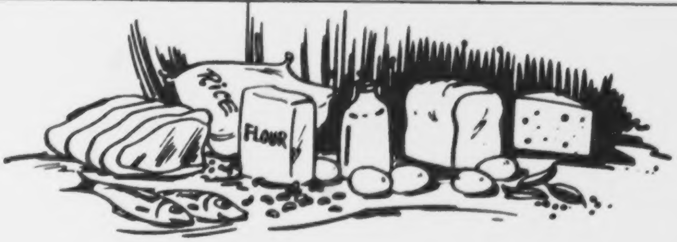
RESOURCE 1: NUTRITION

SOME NUTRIENTS FOUND IN FOOD

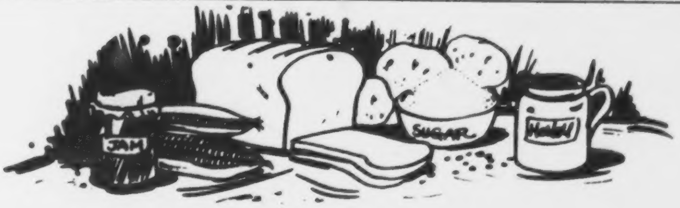
A nutrient is a chemical substance found in food which supplies nourishment to the body. Each nutrient has a special function in the human body.

The following chart identifies some nutrients, their function in the human body, and their source in the foods we eat.

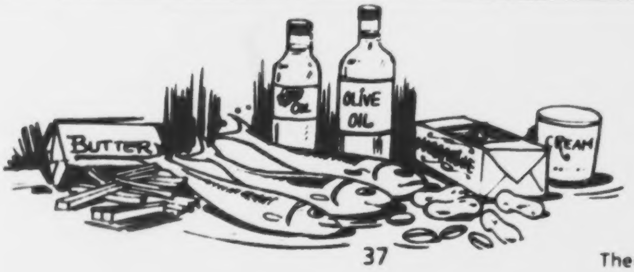
Nutrient	Function	Source
Protein	• Build and repair body tissues	• Meat, fish, poultry, dried beans



Nutrient	Function	Source
Carbohydrates (e.g., sugars, starches, fibres)	• Supply energy for physical and mental activities	• Bread and cereals made of whole grains; carrots, beets, potatoes, beans, peas



Nutrient	Function	Source
Fats	• Supply energy • Help body to use vitamins	• Peanut oils, nuts, butter, cheese, cream, fish oils



RESOURCE 1: NUTRITION (cont'd)

Nutrient	Function	Source
Vitamins	• Regulate the body processes • Prevent disease	
	Vitamin A • Necessary to eyesight • Helps stop infection	• Liver, eggs, yellow and green vegetables, fruits
	Vitamin B • Helps body release energy • Helps to steady nerves	• Wheat germ, liver, pork, poultry, cheese, nuts
	Vitamin C • Helps body repair and heal	• Oranges, lemons, grapefruit, lettuce
	Vitamin D • Helps body absorb calcium, phosphorus • Helps teeth and bones form	• Fish oils, egg yolk, salmon, tuna
	Vitamin E • Helps blood vessels work • Helps body heal	• Green leafy vegetables, peanuts

Nutrient	Function	Source
Minerals	Essential to life • Regulate body functions • Important to the nervous system i.e., iron, calcium, phosphorus, magnesium, zinc, iodine	• Dairy products, green leafy vegetables, eggs

Nutrient	Function	Source
Water	• Important part of all body cells and fluids • Carries nutrients to and wastes from cells • Aids in digestion and absorption of food • Helps to regulate body temperature	• Beverages, soups, fruits, vegetables • Most foods contain some water

THE CANADA FOOD GUIDE

The *Canada Food Guide* is a plan that helps people of all ages meet their nutritional needs. The guide provides information on:

- each of the four basic food groups
- the ingredients of a balanced diet
- a simple daily food plan.

The four basic food groups described in the *Canada Food Guide* are:

- milk and milk products
- fruits and vegetables
- meat, fish, poultry and alternatives
- breads and cereals

MILK AND MILK PRODUCTS

According to the *Canada Food Guide*, the following servings of milk or milk products are needed each day:

Children	2–3 servings
Adolescent	3–4 servings
Adult	2 servings
Pregnant and Nursing Women	3–4 servings

a. Various kinds of milk include:

- skim milk
- low-fat milk (e.g., 1% or 2% milk fat)
- whole milk
- buttermilk
- powdered milk
- evaporated milk

b. If a person is not fond of milk, milk products can be used. These can include:

- cheeses and yogurt
- shakes, eggnogs, cream soups and sauces.

c. Amounts in one serving are:

250 mL (1 cup) milk
175 mL (¾ cup) yogurt
45g (1½ oz) cheese.

d. Milk and milk products contain the following nutrients:

- calcium
- riboflavin
- niacin
- protein
- vitamin D
- vitamin C
- vitamin A

e. Omitting milk from the diet

People who do not drink milk should obtain the nutrients listed above from other foods.

FRUITS AND VEGETABLES

The recommended number of servings of fruits and vegetables each day is:

4–5 servings

a. Choose a variety

- Eat both fruits and vegetables.
- Include citrus fruits such as oranges and grapefruits.
- Include yellow, green, and green leafy vegetables.

b. Eat either raw or cooked. Examples of one serving include:

- 125 mL (½ cup) vegetables/fruits
- 125 mL (½ cup) juice
- 1 medium-sized apple, orange, banana
- 1 medium-sized potato, tomato, carrot.

c. Fruits and vegetables provide the following nutrients:

- vitamin A
- vitamin C
- thiamin
- folacin
- iron
- carbohydrate

MEAT, FISH, POULTRY AND ALTERNATIVES

The recommended amounts of meat, fish, poultry and alternatives needed each day are:

2 servings

a. Those who do not eat meat, fish or poultry may choose from the following alternative foods, which are animal- or vegetable-based products.

Animal-Based	Vegetable-Based
• cheddar cheese • cottage cheese	• peanut butter • nuts or seeds • cooked dried beans, peas and lentils • bean curd (tofu)

b. The major nutrients found in meat, fish, poultry and alternatives are:

- protein
- iron
- vitamins.

BREADS AND CEREALS

The recommended amount of breads and cereals needed each day is:

3–5 servings

a. Foods within this group include:

- bread
- cooked cereals (porridge)
- ready-to-eat cereals
- rolls and muffins
- rice
- pasta (macaroni, spaghetti)

b. Important nutrients in breads and cereals include:

- carbohydrate
- protein
- vitamins and minerals.

c. The following are recommended:

- whole/multigrain breads
- brown rice
- high fibre cereals (bran).

A BALANCED DIET

A balanced diet is necessary for good health. In order to maintain a balanced diet, one should:

- select a variety of foods
- select foods from the four basic food groups
- consider both the quality and quantity of foods that are eaten.

***FAD DIETS* ARE OUT!** ***BALANCED DIETS* ARE IN!**

Do not forget that:

- People of all ages suffer from heart attacks, high blood pressure, and poor nutrition.
- Good eating habits should be developed in the early years. This may decrease the risk of some diseases and health problems later in life.
- A key to good nutrition is to understand potential effects of foods that are eaten on the human body.
- Common sense is always an effective guide. Don't react to fad diets and trendy fast foods.

RESOURCE 1: NUTRITION (cont'd)

PRINCIPLES OF BALANCED DIET

According to the *Canada Food Guide*, a balanced diet provides:

- variety
- energy balance
- moderation

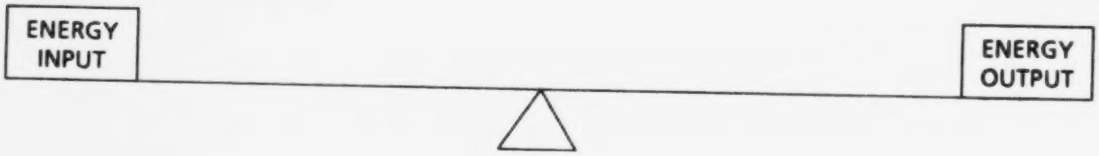
Variety

Variety means choice. A balanced diet lets you choose:

- raw and cooked foods
- different methods of food preparation
- the timing of meals/snacks.

Energy Balance

The food we eat provides us with energy to do things. Our diet should ensure that energy input is in balance with energy output.



Weight loss or weight gain may occur if energy input and energy output are not in balance with one another.

e.g., – malnutrition may result from a poor selection of foods or from improper absorption and use of nutrients by the human body
– undernutrition may result if a person does not eat enough food
– obesity may result from overeating, inactivity or glandular disorders within the human body.

Moderation

Certain foods should be consumed in 'moderation'. These foods include:

- sugars
- salt
- fats

Moderate consumption of these foods may reduce the risk of heart disease, diabetes, high blood pressure, tooth decay and other disturbances within the human body.

RESOURCE 2: MONITORING YOUR DIET

1. Monitor your diet over a seven-day period using the "Weekly Food Intake Chart" provided on the next page.

   Record all that you eat and drink each day for:

   - breakfast
   - lunch
   - dinner
   - snacks.

2. Calculate your nutritional score by completing the table provided below.

Food Group	Daily Servings	Total	Maximum Score
Milk and milk products 3–4 servings	M T W T F S S ☐☐☐☐☐☐☐	☐	28
Meat, fish, poultry and alternatives 2 servings	M T W T F S S ☐☐☐☐☐☐☐	☐	14
Fruits and vegetables 4–5 servings	M T W T F S S ☐☐☐☐☐☐☐	☐	35
Breads and cereals 3–5 servings	M T W T F S S ☐☐☐☐☐☐☐	☐	35
			112
	Deduct 10 points for missing a meal		
		Final Score	

3. Did your diet during the seven-day period reflect variety, energy balance and moderation? Why or why not?

WEEKLY FOOD INTAKE CHART

DATE ______________ to ________________

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Breakfast							
Lunch							
Dinner							
Snacks							

RESOURCE 3: BODY MASS INDEX

HOW TO FIND YOUR BMI – IT'S EASY

1. Mark an X at your height on line A.
2. Mark an X at your weight on line B.
3. Take a ruler and join the two X's.
4. To find your BMI, extend the line to line C.

FOR EXAMPLE:

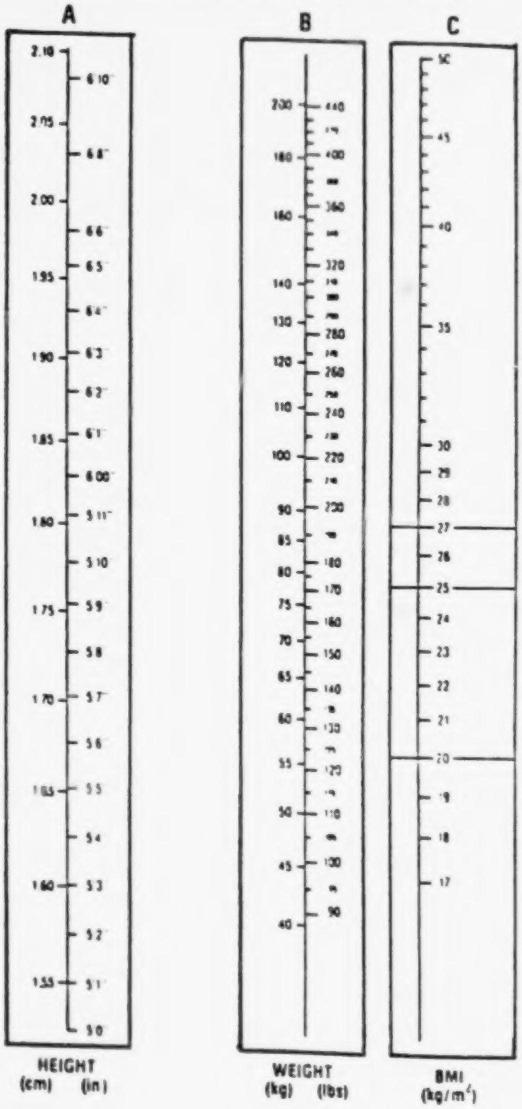
- If Michael is 5'11" (1.80 m) and weighs 188 lbs (85 kg), his BMI is about 26.
- If Irene is 5'4" (1.60 m) and weighs 132 lbs (60 kg), her BMI is about 23.

Under 20 A BMI under 20 may be associated with health problems for some individuals. It may be a good idea to consult a dietitian and physician for advice.

20-25 This zone is associated with the lowest risk of illness for most people. This is the range you want to stay in.

25-27 A BMI over 25 may be associated with health problems for some people. Caution is suggested if your BMI is in this zone.

Over 27 A BMI over 27 is associated with increased risk of health problems such as heart disease, high blood pressure and diabetes. It may be a good idea to consult a dietitian and physician for advice.



IF YOU FALL BELOW 20 OR ABOVE 27 ON THE BMI RANGE . . .

It's time to reduce your chance of developing health problems. The first and most important thing is to determine why you are not within the healthy weight range and seek the assistance of your physician and dietitian/nutritionist.

Be aware that the Body Mass Index has been designed to assist adults in determining a healthy weight range. Adolescents who have not completed their physical growth should exercise caution when interpreting a BMI.

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RESOURCE 4: HEARTBEAT RECOVERY RATES

Your pulse rate provides information about your health. In this investigation, you will be required to collect data about your personal health by determining your pulse rate after various kinds of activity. Pulse rate can be determined by counting the number of times your heart beats in 15 seconds and multiplying by 4. You will also be required to construct a line graph which will be used to summarize the data you collect about your health.

A. In the following activity, you will find your pulse rate when at rest and after a period of exertion. Perform each activity listed in the chart. Record your pulse rate after performing each activity. Always take your pulse while sitting down.

Activity	Pulse Rate (Beats Per Minute)
1. Sit for 3 minutes.	
2. Stand and sit 10 times.	
3. Sit for 3 minutes.	
4. Touch your toes 10 times.	
5. Sit for 3 minutes.	
6. Jump 20 times, clapping your hands above your head.	
7. Sit for 3 minutes.	
8. Run on the spot for 1 minute.	
9. Sit for 3 minutes.	
10. Sit for another 3 minutes.	

B. Using the information that you recorded in Part A, draw a line graph illustrating changes in your pulse rate.

C. What observations can you make about the speed at which your heart recovered from the activities undertaken?

D. Compare your heartbeat recovery rate following certain activities with the recovery rates noted by other members of the class.

RESOURCE 5: WHAT ISSUES SURROUND THE USE OF LIFE SUPPORT SYSTEMS?

PURPOSE

To show that the use of a technological process or device may lead to serious moral, ethical, constitutional or legal questions and issues.

INTRODUCTION

Medical advances in recent years have raised questions about death which did not exist in earlier times. In the past, death occurred clinically when heartbeat and breathing stopped. Now, with artificial life support systems, these functions can often be maintained for long periods of time, even years. As a result, a new definition of death, brain death, is becoming accepted. Brain death occurs when spontaneous brain function ceases. Because transplant organs are best taken as soon as possible from a dying person, defining the point of death is particularly important when that person is donating organs. The legal definition of death is no longer as simple as it used to be.

At the same time, prolonging life artificially can cause pain for the patient, expense for the family and society, and suffering for relatives. Some people object to the enforced use of life support systems. They argue that these systems are violating a basic human right, the "right-to-die", and to do so with dignity. The right-to-die conflicts with other social issues: the sanctity of life; the "sin" of suicide; or even what constitutes murder.

In response to the technology of life support, some people have drawn up "living wills". A living will instructs doctors to cease artificial life support when there is no way for a person to recover, and when there is great pain and suffering.

A living will is an attempt to create a legal document that allows a person to decide about death while the person is still capable of rational decisions. Living wills and the right-to-die concept are still very controversial.

MATERIALS

Recent newspaper and magazine articles about issues surrounding life support systems.

PROCEDURE

A. Read several articles about the issues surrounding the use of life support systems.

B. As a class, discuss the following questions:

   (1) Should people be allowed to decide for themselves the conditions under which they should be allowed to die? Why or why not?

   (2) Should life be sustained as long as possible?

   (3) Are doctors, nurses, or relatives even justified in "pulling the plug"?

RESOURCE 5: WHAT ISSUES SURROUND THE USE OF LIFE SUPPORT SYSTEMS? (cont'd)

(4) How could society resolve the conflict between an individual's "right-to-die" and society's duty to protect human life?

(5) Should living wills be legally binding?

(6) Could living wills and the right-to-die be abused?

RESULTS

Students should begin to understand that many issues can arise when a new technological process or device is adopted. These issues have no easy resolution, especially when individuals' attitudes on the issues depend on the particular values they hold.

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THEME B
CHEMISTRY FOR THE CONSUMER

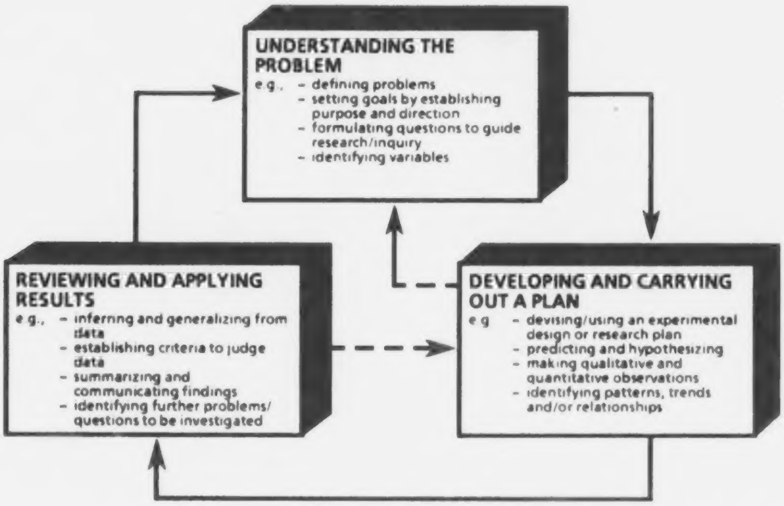
Learning objectives will focus attention on the chemical properties and active ingredients of substances used by students in their everyday lives. By carrying out a series of controlled experiments, students will investigate the composition of a variety of familiar household products and the scientific principles that underlie their effectiveness. Students will be expected to develop strategies for:

- safely handling potentially dangerous substances and situations encountered within the home and work environments
- selecting consumer products on the basis of their active ingredients and ability to accomplish a given task.

A primary emphasis should be placed on gathering information about familiar chemical products through research and experiment. A focus on the nature of science and the inquiry process will enable students to understand the way in which knowledge of chemical substances is gathered, as well as use appropriate processes to conduct investigations of their own. Teachers are encouraged to reference the "Program Emphases and Methodology" section of this manual when planning for instruction. Suggestions particularly relevant to the learning objectives addressed in this theme can be found in:

- Nature of Science.
- Communication Skills.
- Assessment/Evaluation.

A FRAMEWORK FOR INVESTIGATING CHEMICAL PRODUCTS


UNDERSTANDING THE PROBLEM
e.g., - defining problems
- setting goals by establishing purpose and direction
- formulating questions to guide research/inquiry
- identifying variables
DEVELOPING AND CARRYING OUT A PLAN
e.g. - devising/using an experimental design or research plan
- predicting and hypothesizing
- making qualitative and quantitative observations
- identifying patterns, trends and/or relationships
REVIEWING AND APPLYING RESULTS
e.g., - inferring and generalizing from data
- establishing criteria to judge data
- summarizing and communicating findings
- identifying further problems/questions to be investigated

CONCEPTS, SKILLS AND ATTITUDES

CONCEPTS

Students will be expected to demonstrate an understanding that:

- the properties of household solutions are different than those of pure substances
  - describes the properties of solutions and the properties of pure substances
  - distinguishes between familiar household substances that are pure and those that are solutions, giving examples of each
- permanent suspensions (e.g., foams, emulsions) have useful properties and a variety of applications in the home
  - describes the properties of permanent suspensions
  - identifies examples of familiar permanent suspensions used in the home
  - explains the importance of permanent suspensions by relating the consequences of separation to common household products and situations
- acids and bases have useful properties and a variety of applications in the home
  - describes how acids and bases can be identified according to their natural properties
  - identifies examples of familiar acids and bases used in the home
  - illustrates how acids and bases can react with other household substances in both useful and potentially dangerous ways
- solubility varies with temperature
  - demonstrates how temperature change affects the solubility of one familiar household solute
  - cites real life situations in which temperature change affects solubility
  - explains the concept of unsaturated, saturated and supersaturated solutions
- many chemical reactions may require or emit energy in the form of heat
  - distinguishes between types of household reactions that require heat energy and those that produce heat energy
  - explains the usefulness of household reactions that require and produce heat energy
- heat flows from areas of high temperature to areas of lower temperature
  - compares heat exchange by conduction, convection and radiation in different mediums
  - determines the mode of heat transfer involved in familiar processes used at home and work
- handling, storing and using potentially hazardous chemical products requires knowledge and care
  - identifies common substances that have safety labelling
  - explains why it is important to read instructions for safe handling
  - cites the potential dangers of mixing certain household products
  - describes recovery techniques for common errors in handling.

SKILLS

Students will be expected to demonstrate an ability to:

- conduct experiments that illustrate the properties of pure substances and solutions
- through class discussion, design experiments that illustrate factors affecting solubility, the differences between temporary and permanent suspensions, and the behaviour of acid and base substances
- use apparatus and equipment effectively when conducting experiments
- make qualitative and quantitative observations when conducting experiments
- identify patterns and relationships in the behaviour of substances and solutions investigated, and apply this information by explaining how selected chemical products and reactions are used in performing routine tasks (e.g., cooking, cleaning)
- predict heat exchange in practical situations, and use appropriate procedures for protecting living organisms and other materials from excessive heat transfer
- accurately read product labels and consumer reports in order to determine the composition and intended use of familiar household products
- apply appropriate techniques for identifying acids, bases and other chemical substances
- use safe procedures for handling and storing potentially dangerous substances.

ATTITUDES

Students will be encouraged to:

- display a positive attitude toward the learning of concepts and skills in science
    - shows interest and curiosity through willingness to ask questions, share observations and ideas, and seek answers
    - performs investigations and completes assignments independently and in cooperation with others
- value scientific principles and processes for their usefulness in providing an understanding of common household phenomena
- appreciate the usefulness of measurement skills in real life and work-related situations
- appreciate the role of technology in solving practical problems
- appreciate both the usefulness and potential hazards of common household substances
- display a respect for personal safety and the safety of others when handling potentially hazardous substances
- appreciate the contributions of science and technology to the development of a variety of materials and products that we depend upon and use each day.

INTEGRATION ACTIVITIES

ENGLISH

Students will use a variety of communication skills throughout investigations that are undertaken in this theme. Through cooperative conferencing, English and science teachers may wish to plan integrated activities that will enable students to:

- write directions for special safety procedures (e.g., mixing reagents) and sequential tasks (e.g., lighting a bunsen burner)
- prepare laboratory reports for experiments that have been performed.

Suggestions and ideas that may assist students to develop and use communications skills in science are provided in another section of this manual (see "Communication Skills").

MATHEMATICS

Students will use mathematical concepts and skills when they:

- measure length, mass, capacity, time and temperature
- use ratio and proportion to determine appropriate ingredients for mixtures and solutions
- interpret measures of central tendency
- interpret and display data in table/chart/graph form.

Science teachers are encouraged to confer with mathematics teachers in establishing appropriate strategies for reinforcing mathematical competencies. Teachers may wish to plan integrated activities that will enable students to:

- use appropriate statistical methods to interpret and display data gathered through experiments performed in science class
- use ratio/proportion/percent to describe the composition of familiar chemical products.

SOCIAL STUDIES

Students will develop an understanding of issues related to the use of chemical products in the local community through activities in current affairs. Cooperative planning between the social studies and science teachers may provide opportunities for students to:

- investigate applications of chemical products in the community
- consider appropriate strategies for handling and using chemical products
- identify environmental concerns associated with the use of particular chemical products.

OCCUPATIONAL COURSES

Students will use a variety of chemical substances and solutions in their occupational courses. These products may include:

- oils/lubricants
- cleaning agents
- paints
- chemicals used in photography
- baking products
- glues/adhesives
- fertilizers/pesticides
- personal care products.

Cooperative conferencing among science and occupational teachers will assist in planning integrated activities that enable students to investigate the chemical properties and active ingredients of the substances they use in work-related situations.

COMMUNITY PARTNERSHIP OPPORTUNITIES

The local community may offer a variety of resources that contribute to the development of learning objectives within this theme. Suggestions for using these resources, and for developing an understanding of chemical products through situational and concrete learning experiences in the community are provided below.

- Invite a local pharmacist to discuss the chemical properties/active ingredients of mixtures and solutions used in personal care products.

- Invite representatives from local industry (e.g., hair care, dry cleaning, automotive, food preparation) to discuss the chemical properties/active ingredients of mixtures and solutions used in their respective service areas.

- Visit local industry and observe applications of chemical products/processes and the safety precautions taken by workers.

- Invite a local agriculturalist/soil expert to discuss the effects of soil acidity on plant growth, and the methods of adjusting acid level in soil.

- Visit local stores and gather information about familiar consumer products by reading product labels.
  e.g.,
    - hazardous chemical symbols
    - product composition
    - active ingredients
    - applications
    - directions for use
    - recovery techniques for errors in handling

- Invite an environmentalist to speak to the class about environmental problems caused by the disposal of chemical substances.

- Invite a local doctor/health nurse to discuss health concerns related to the use of chemical products.
  e.g.,
    - the potential dangers of using and/or mixing particular substances
    - recovery techniques/emergency treatment for errors in handling hazardous substances.

- Invite a paramedic/fire chief to discuss safety considerations related to the use of chemical products.
  e.g.,
    - the hazards and safe handling/storage techniques for potentially dangerous products found in the home and/or workplace
    - methods of minimizing the occurrence of fires in the home and/or workplace
    - appropriate methods of extinguishing different types of fires

- Use the local/national newspapers to identify current environmental issues related to the use of chemical substances. Provide opportunities for students to discuss and debate the issues that are identified.

RESOURCE CORRELATION

BASIC RESOURCE

ISIS Individualized Science Instructional System
Booklet: *Household Science*

SUPPORT RESOURCES

Science at Work Series
Booklet: *Cosmetics*

OTHER RESOURCES

Applied Science, Book 1
Unit 5 – Measurements of All Kinds
Unit 8 – Water: Our Most Precious Fluid

Applied Science, Book 2
Unit 4 – Solvents Other Than Water
Unit 5 – Acids and Salts: Part of Our Everyday Life

Chemistry in Everyday Life (video program)

Principles of Science, Book 1
Chapter 1 – Science and Measurement
Chapter 2 – Matter
Chapter 3 – Energy and Changes in Matter

Principles of Science, Book 2
Chapter 10 – Matter
Chapter 13 – Chemical Technology
Chapter 14 – Heat

The Scientific Method (video program)

Science Networks: Physical Science
Unit 2 – Chemical Change
Unit 3 – Heat
Unit 7 – Measurement in the Metric System

SUGGESTED ACTIVITIES

The student learning resources identified above provide a variety of instructional activities that support learning objectives identified in this theme. The activities that follow complement those provided in the student learning resources. Teachers should be selective in their use, and consider students' interests/abilities and preferred methods of learning in planning appropriate instructional activities.

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LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING THAT THE PROPERTIES OF HOUSEHOLD SOLUTIONS ARE DIFFERENT FROM THOSE OF PURE SUBSTANCES.

- **Describes the properties of solutions and the properties of pure substances.**
- **Distinguishes between familiar household substances that are pure and those that are solutions, giving examples of each.**

RESOURCE CORRELATION

BASIC RESOURCE

Household Science
Chapter 1 – Home Sweet Home
Chapter 2 – How Much and How Many?
Chapter 3 – Water Doesn't Act Like Milk
Chapter 8 – Solutions Don't Act Like Pure Substances

SUPPORT RESOURCE

Cosmetics
Chapter 2 – Making Cosmetics
Chapter 8 – Toothpaste

1. Collect labels from a variety of chemical products used in the home. Classify each product according to its function/use (e.g., detergent, solvent, leavening agent). Investigate the composition/ingredients of each product. Summarize information in a table like the one illustrated below.

CLARIFICATION/EXAMPLE

CHEMICAL PRODUCT	FUNCTION/USE	COMPOSITION/INGREDIENTS

2. Perform a variety of experiments in order to determine the properties of pure substances and solutions frequently used at home and in work-related situations.

   As experiments are performed, provide opportunities for students to make "qualitative" and "quantitative" observations, and to develop descriptive writing skills in order that observations can be accurately recorded. Suggestions for developing and evaluating these skills are provided in the "Nature of Science" section of this manual (see Resource 4: Observing and Describing and Resource 5: An Evaluation Guide for Observations).

3. Define problems and formulate questions related to:

   - methods of separating partners of a mixture
   - factors affecting the solubility of substances
   - the effects of a solute on the freezing/boiling point of a solution.

   Through discussion and modelling, help students to design experiments that may solve problems and answer questions that have been identified. Suggestions for designing and planning experiments are provided in Nature of Science, "Useful Strategies and Skills".

4. Identify familiar household solvents other than water (e.g., dry cleaning products, paint thinners). Investigate and discuss:

   - the chemical properties/appropriate applications of these solvents
   - hazards and safety precautions related to the use of solvents in the home
   - recovery techniques for common errors in handling household solvents (e.g., a solvent spill, ingestion of a solvent).

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING OF THE PROPERTIES OF PERMANENT SUSPENSIONS (E.G., FOAMS, EMULSIONS) USED IN THE HOME.

- **Describes the properties of permanent suspensions.**
- **Identifies examples of familiar permanent suspensions used in the home.**
- **Explains the importance of permanent suspensions by relating the consequences of separation to common household products and situations.**

RESOURCE CORRELATION

BASIC RESOURCE

Household Science
Chapter 11 – Popcorn and Other Suspensions

SUPPORT RESOURCE

Cosmetics
Chapter 3 – Emulsions and Skin Creams

1. Identify familiar permanent suspensions used in the home (e.g., foams, emulsions, gels). Investigate the composition of these products, and perform experiments in order to determine their properties.

   e.g., – What happens to the particles in a suspension when it is left standing?
   – How can particles of a suspension be removed?

2. Investigate the process used in producing a familiar household suspension.

   e.g., – How is homogenized milk produced?
   – How are butter and cream made?

   Structure research activities using suggestions provided in the "Communication Skills" section of this manual.

3. Relate knowledge of suspensions to the manufacture and use of personal care products. Identify the active ingredients and useful properties of soap, skin creams, toothpaste and perfumes by conducting one or more of the investigations described in *Cosmetics* (Science at Work Series).

4. Provide opportunities for students to evaluate media claims for a personal care product by distinguishing between the product's active/useful ingredients and other ingredients that simply increase the appeal of the product. Compare the useful properties of the product to actual claims made about the product by the media.

e.g., – "Fluffy Shampoo. What could be more natural?"
– "Tests proved Brand X more effective in reducing tooth decay."
– "Wonder Skin Cream reduces wrinkles by 50%."

Encourage students to consider relationships between the cost and the effectiveness of personal care products they use, and to identify alternative personal care products and/or practices that may be less expensive but equally effective.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING OF THE PROPERTIES OF ACID AND BASE SUBSTANCES USED IN THE HOME.

- **Describes how acids and bases can be identified according to their natural properties.**
- **Identifies examples of familiar acids and bases used in the home.**
- **Illustrates how acids and bases can react with other household substances in both useful and potentially dangerous ways.**

RESOURCE CORRELATION

BASIC RESOURCE

Household Science
Chapter 4 – Acids and Bases

SUPPORT RESOURCE

Cosmetics
Chapter 4 – Soap
Chapter 5 – Hard and Soft Water

1. Conduct experiments that demonstrate the properties of familiar acid and base substances used at home and in work-related situations. Classify substances as acid, base or salt according to the results of investigation.

e.g., Familiar **acids** may include citric acid, boric acid, milk, vinegar, aspirin and battery acid.

Some properties of acids include:
- acids taste sour
- acids turn blue litmus paper red
- acids wear away metals
- acids cause colour change

Familiar **bases** may include milk of magnesia, lye, ammonia, baking soda and fertilizer.

Some properties of bases include:
- bases taste bitter
- bases feel slippery or soapy
- bases turn red litmus paper blue
- bases destroy the properties of an acid
- bases dissolve fats and oils

Students should be warned not to taste substances/products used in the science laboratory unless appropriate procedures in microbiology have been followed.

2. Conduct experiments that demonstrate how properties of acids and bases enable them to react with other substances in useful ways.

   e.g.,
   - sour milk and its effect on baking soda in the production of baked goods
   - the use of lemon juice to dispel fish odours
   - the removal of stains with vinegar
   - hair shampoo and rinse
   - antacids for the stomach
   - oven and drain cleaners
   - the actions of soaps and detergents

3. Examine the warning labels on a variety of acid and base substances used in the home. Discuss the importance of accurately identifying acid and base substances, and how their properties may cause potentially dangerous reactions with other household substances.

   e.g.,
   - Ammonia and vinegar look alike. What would happen if you used ammonia instead of vinegar (or vice versa)?
   - Consider the potential dangers of mixing:
     bleach and drain cleaners
     ammonia and bleach
     ammonia and aluminum

4. Identify acids present in the body and discuss their role in the digestive process.

   Perform experiments in order to determine the effect of familiar antacids on a dilute solution of hydrochloric acid. Relate the results of experimentation to the use of antacids in neutralizing excess acidity in the digestive system.

   Identify and compare the ingredients/composition of various "brand name" antacids and other digestive aids. Evaluate media claims for these products by considering properties of the active ingredients present in these products.

   e.g.,
   - "Twice the pain relief that doctors recommend most."
   - "Helps prevent, helps fight."

5. Conduct experiments to test the effect of soil acidity on the growth of different kinds of plants. Include experimental control in the design of investigations by varying soil acidity but keeping constant other factors that affect plant growth.

   Discuss local methods of controlling acid levels in soil (e.g., adding lime or humus).

6. Coach students in the use of skills appropriate to organizing and communicating the results of the experiments they perform by using suggestions provided in another section of this manual (see Nature of Science).

   While students may not write a laboratory report for each experiment they perform, suggestions that will help students to summarize major events of an investigation are provided in the Nature of Science, Resource 1: Writing a Lab Report, Resource 2: A Sample Lab Report, and Resource 3: An Evaluation Guide for Lab Reports.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING THAT SOLUBILITY VARIES WITH TEMPERATURE.

- **Demonstrates how temperature change affects the solubility of one familiar household solute.**
- **Cites real life situations in which temperature change affects solubility.**
- **Explains the concept of unsaturated, saturated and supersaturated solutions.**

RESOURCE CORRELATION

BASIC RESOURCE

Household Science
  Chapter 9 – Hot and Cold Solutions
  Chapter 10 – Candy and Crystals

1. Assist students to design and conduct an experiment that illustrates how temperature affects the solubility of a familiar solute.

   e.g., – sugar in water
   – tea/coffee in water
   – gelatin crystals in water
   – salt in water
   – oil in water

   Discuss factors other than temperature that affect the solubility of substances (e.g., particle size, mechanical movement).

2. Identify practical situations in which temperature change is used to increase/decrease the solubility of a substance.

   e.g., – brine preparation when pickling
   – syrup preparation when canning fruit
   – making gelatin, syrups and sauces

3. Investigate the use of unsaturated, saturated and/or supersaturated solutions in the manufacture of a food product.

   e.g., – rock candy
   – fruit juice
   – a dairy product

   Organize and summarize the results of investigation, using suggestions provided in "Communication Skills".

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING THAT MANY CHEMICAL REACTIONS MAY REQUIRE OR EMIT ENERGY IN THE FORM OF HEAT.

- **Distinguishes between types of household reactions that require heat energy and those that produce heat energy.**
- **Explains the usefulness of household reactions that require and produce heat energy.**

RESOURCE CORRELATION

BASIC RESOURCE

Household Science
Chapter 5 – Heat and Household Reactions
Chapter 6 – Heat Flow, Gelatin and Soup

SUPPORT RESOURCES

Cosmetics
Chapter 9 – Perfumes and Essences

Teacher Resource Manual
Resource 1: Combustible and Flammable Materials

1. Identify and describe useful types of household reactions that require heat energy.

   e.g., – preparation of gravies and sauces
   – melting substances like butter and chocolate
   – dissolving substances
   – operation of a humidifier

   Investigate situations where heat and temperature may affect the rate at which a household product reacts with other substances. Generalize the results of investigation by inferring:

   - appropriate procedures for using the product
   - safe storage practices.

2. Identify and describe useful types of household reactions that emit heat energy.

   e.g., – operation of refrigeration/air conditioning
   – home heating
   – use of drain cleaners
   – epoxy-type reactions

3. Investigate familiar oxidation reactions that occur naturally in our environment, and how these processes also emit heat energy.

   e.g., – respiration
   – rusting and corrosion
   – food decay
   – spontaneous combustion

   Identify procedures that can be used to control the negative effects of these reactions.

   e.g., – inhibiting rust/corrosion by coating materials with paint
   – reducing the risk of spontaneous combustion by providing adequate ventilation
   – reducing food decay through refrigeration and the use of airtight packaging

An explanation of the "fire triangle" and guidelines for controlling different types of combustion are provided in Resource 1: Combustible and Flammable Materials.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING THAT HEAT FLOWS FROM AREAS OF HIGH TEMPERATURE TO AREAS OF LOWER TEMPERATURE.

- **Compares heat exchange by conduction, convection and radiation in different mediums.**
- **Determines the mode of heat transfer involved in familiar processes used at home and at work.**

RESOURCE CORRELATION

BASIC RESOURCE

Household Science
Chapter 6 – Heat Flow, Gelatin and Soup
Chapter 7 – Heat Flow, Conservation and Safety

1. Investigate heat exchange through conduction by designing experiments that illustrate differences among the conduction rates of familiar materials. Use the results of investigation to prepare a list of "good" and "poor" conductors of heat. Relate knowledge of conduction to the use of appropriate materials and equipment in the kitchen.

   e.g., – metal cookware for the stove
   – heat insulators such as oven mitts, plastic and wooden utensils

2. Conduct experiments that demonstrate how heat may be transferred through air, water and/or other fluids by convection. Draw diagrams that illustrate how heat is transferred by convection in practical situations.

   e.g., – transfer of heat by convection in the home
   – convection currents in a refrigerator
   – convection currents in a hot-water tank
   – land and sea breezes

3. Conduct experiments that demonstrate how heat may be transferred by radiation. Investigate the basic principles of solar heating. Provide opportunities for students to draw diagrams/construct models of an active and/or passive solar heating system.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING OF SAFE PROCEDURES FOR HANDLING, STORING AND USING POTENTIALLY HARMFUL CHEMICAL PRODUCTS USED IN THE HOME AND AT WORK.

- **Identifies common substances that have safety labelling.**
- **Explains why it is important to read instructions for safe handling.**
- **Cites the potential dangers of mixing certain household products.**
- **Describes recovery techniques for common errors in handling.**

RESOURCE CORRELATION

BASIC RESOURCE

Household Science
Chapter 12 – Safe at Home

SUPPORT RESOURCE

Teacher Resource Manual
Resource 2: WHMIS Hazard Symbols for Controlled Products
Resource 3: Hazard Symbols for Consumer Products

1. Assemble a display of "product labels" found on a variety of chemical substances used in the home (e.g., detergents, cleaning fluids, personal hygiene products, pesticides, prescription and non-prescription drugs). The display may include:

   - the brand name of each product
   - the chemical name of each product
   - an appropriate hazard symbol (if required)
   - safe procedures for using/storing each product
   - recovery techniques for errors in handling.

2. Contact the "Poison Control Centre" in your area for information concerning:

   - safe handling procedures for chemical products frequently used at home or in work-related situations
   - emergency treatment/recovery techniques for errors in handling these chemical products.

3. Through brainstorming, formulate a list of "do's" and "don'ts" for handling/storing potentially hazardous chemical products. Simulate a variety of practical situations that involve the use of these hazardous products, and ask students to describe appropriate procedures and actions in each situation.

   Invite a pharmacist/doctor/paramedic to class. Ask this person to:

   - evaluate the safety procedures and actions formulated by students
   - suggest other procedures and recovery techniques that may be appropriate in these situations.

4. Provide opportunities for students to identify, interpret and draw the hazard symbols that are used in classifying:

   - controlled products (see Resource 2: WHMIS Hazard Symbols for Controlled Products)
   - other consumer products that are potentially dangerous (see Resource 3: Hazard Symbols for Consumer Products).

   Other resources that may assist students to interpret hazard symbols at home and in work-related situations include:

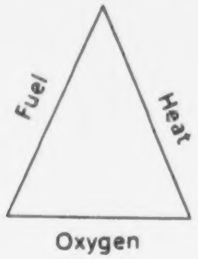
   - *WHMIS: Working for You* (a video program available from the nearest Regional Office of Alberta Occupational Health and Safety)
   - *Stop and Save a Life* (a pamphlet available from Consumer and Corporate Affairs Canada).

   Additional safety information is provided in the *Occupational Health and Safety Magazine*, published quarterly by Alberta Occupational Health and Safety.

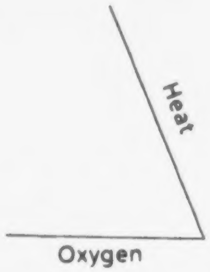
RESOURCE 1: COMBUSTIBLE AND FLAMMABLE MATERIALS

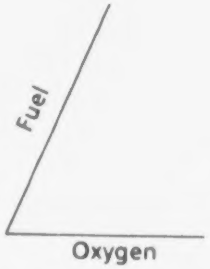
THE FIRE TRIANGLE

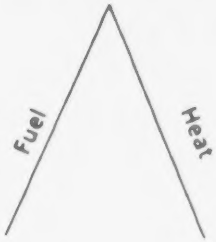
Combustion requires that the three elements illustrated below be present at the same time.



If any one of these three elements is missing, combustion cannot occur. Therefore, if any one of these elements is removed from a fire it will be extinguished.







TYPES OF FIRES

Two words that describe materials that burn are **combustible** and **flammable**. If something is combustible or flammable it will burn easily. Combustible and flammable materials found in the workshop may include paint, oil and cloth rags.

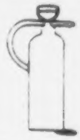
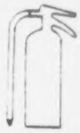
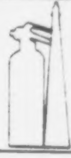
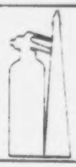
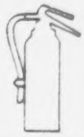
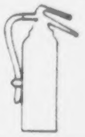
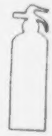
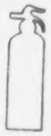
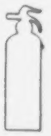
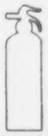
Fires are identified by the type of fuel or burning material.

TYPE 'A' FIRES	– occur in ordinary combustible materials e.g., wood, paper and cloth
TYPE 'B' FIRES	– occur with flammable liquids e.g., grease, gasoline, paint and oil
TYPE 'C' FIRES	– occur in electrical equipment and wiring e.g., motors, electrical outlets and electrical switches

CONTROLLING COMBUSTION

Fire extinguishers are frequently used to control combustion. The type of fire extinguisher selected to put out a fire should be determined by the type of fire. The chart indicates what type of extinguisher should be used for each type of fire.

Alberta
LABOUR
General Safety Services Division
Fire Prevention Branch

		TYPE OF FIRE				
TYPE OF EXTINGUISHER		**A** ORDINARY COMBUSTIBLES • wood • paper • cloth etc	**B** FLAMMABLE LIQUIDS • gasoline • paints (oil based) • oils etc	**C** ELECTRICAL EQUIPMENT • motors • switches	RANGE	HOW TO OPERATE
WATER	WATER PUMP TANK		**NO**	**NO**	9m to 12m	Place foot on footrest pump handle and direct stream at base of flame
	STORED PRESSURE		**NO**	**NO**	9m to 12m	Pull pin rupture cartridge if applicable squeeze nozzle to release agent Direct discharge at base of flames in a sweeping motion then direct it gradually forward or at remaining material that is burning
CO_2		**NO**			1m to 1 5m	
HALON		**YES** (if classification rating is IA or greater)			2 5m to 4 5m	
DRY CHEMICAL	ORDINARY	**NO**			1 5m to 6m	
	MULTI-PURPOSE				5m to 7 5m	NOTE All extinguishers require annual servicing or servicing after use

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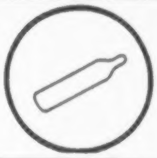
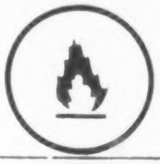
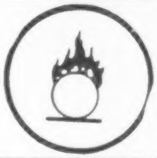
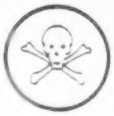
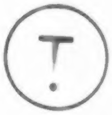
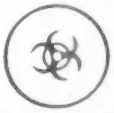
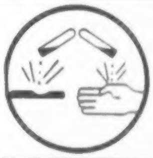
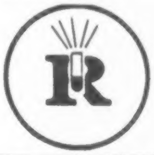
RESOURCE 2: WHMIS HAZARD SYMBOLS FOR CONTROLLED PRODUCTS

CLASS	CONTROLLED PRODUCT	SYMBOL
A	COMPRESSED GAS	
B	FLAMMABLE AND COMBUSTIBLE	
C	OXIDIZING MATERIAL	
D	POISONOUS AND INFECTIOUS MATERIAL 1. MATERIAL CAUSING IMMEDIATE AND SERIOUS TOXIC EFFECTS 2. MATERIAL CAUSING OTHER TOXIC EFFECTS 3. BIOHAZARDOUS INFECTIOUS MATERIAL	  
E	CORROSIVE MATERIAL	
F	DANGEROUSLY REACTIVE MATERIAL	

RESOURCE 3: HAZARD SYMBOLS FOR CONSUMER PRODUCTS

The Hazardous Product Act was developed to help control the number of poisonings and injuries from household products occurring to small children and adults. Since 1969, the Department of Consumer and Corporate Affairs has been active in regulating hazardous products, banning those which are found to be injurious to health.

The Act divides hazardous products into two categories.

The first category deals with products that are so dangerous that they would expose the public to unacceptable hazards and are banned. There are twenty-three items listed under Part 1, including: poisonous jequirity beans, scarlet and black beans used as decoration on toys or in beaded jewellery; children's furniture and other children's articles painted with coatings containing harmful amounts of lead and other chemical compounds; textile fibres which are highly flammable (children's sleepwear has even stricter standards than other fibres); baby teethers and pacifiers containing contaminated liquids; non-safety glass on shower doors, storm doors and bathtub enclosures; and hockey helmets that do not meet prescribed safety standards.

The second category of the Act deals with products that may be imported, advertised and sold in Canada only under conditions stipulated in the regulations. Some of these products are: bleaches, cleansers and sanitizers containing chlorine; products containing petroleum distillates, antifreeze, turpentine, acids, alkalines and methyl hydrate; aerosol containers; glazed ceramics; science education sets; children's car seats; charcoals, matches; and electric kettles.

LABELLING OF HOUSEHOLD PRODUCTS

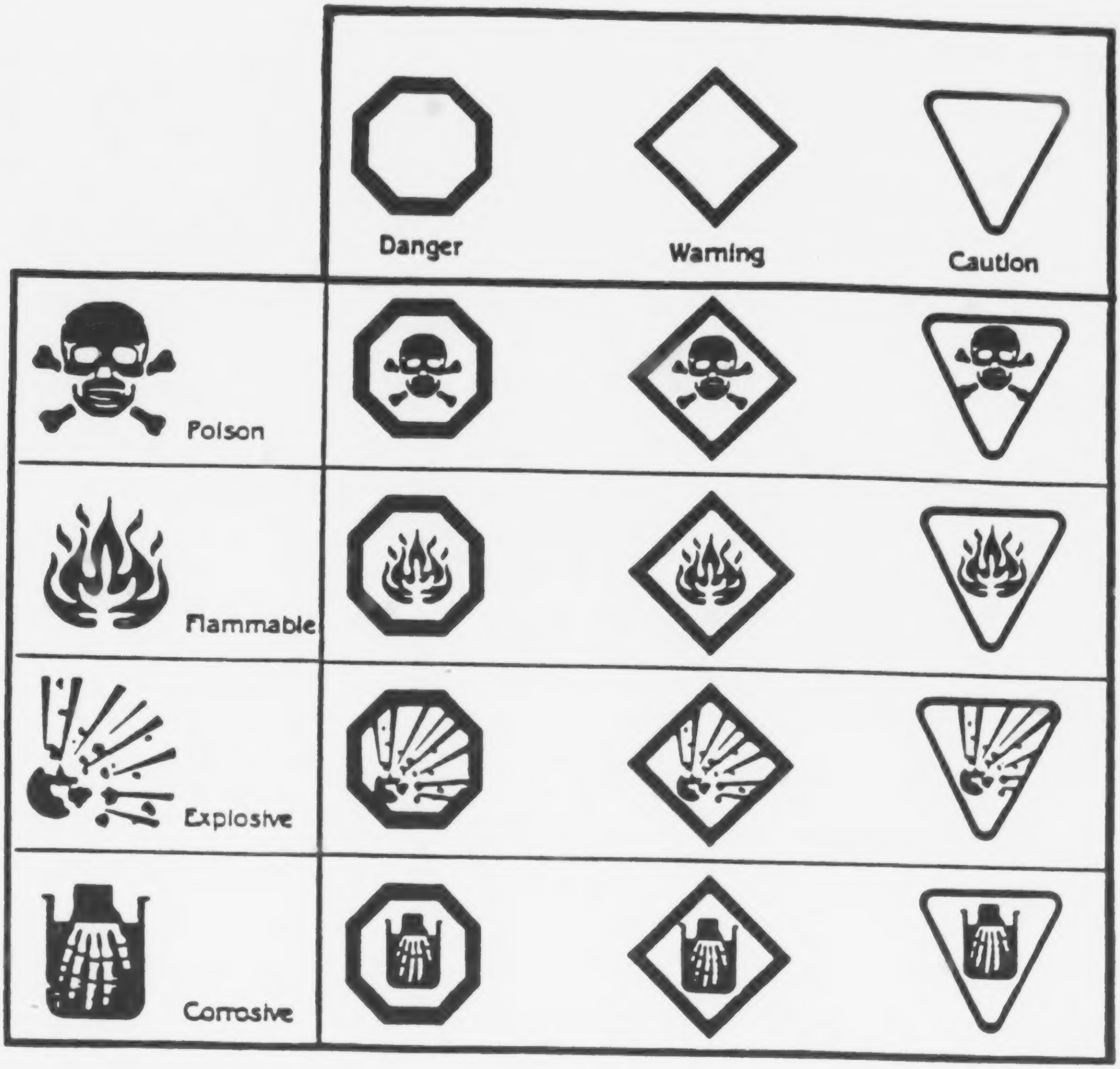
Household chemicals, listed under Part 2 of the Hazardous Product Act (cleaners, bleaches, polishes, glues, sanitizers, antifreeze and aerosol cans) must be labelled to indicate any hazards, including combinations, and the recommended first aid instructions if mishandled. An easily understood set of symbols was designed.

Three degrees of hazard have been established:

- DANGER (it could kill you)
- WARNING (it could make you ill or hurt you); and
- CAUTION (it could make you ill).

Four types of hazards have been determined: poisonous, flammable, explosive, and corrosive. Put together, they make the accompanying 12 basic symbols:

RESOURCE 3: HAZARD SYMBOLS FOR CONSUMER PRODUCTS (cont'd)



HERE IS AN EXAMPLE: For one type of volatile paint thinner, two symbols would be used: a skull and crossbones in an octagon meaning danger, poison; a flame in a diamond meaning warning, flammable. The first aid treatment must be stated this way, "Contains petroleum distillate. If swallowed, do not induce vomiting. Call physician immediately. If patient is unconscious, give him air".

From *Consumer's Guide, Co-op Consumer Counsellor*, pp. C17-C18, by Federated Co-operatives Limited. Copyright 1983 by Federated Co-operatives Limited. Reprinted by permission.

THEME C
USING SYSTEMS AND TECHNOLOGIES

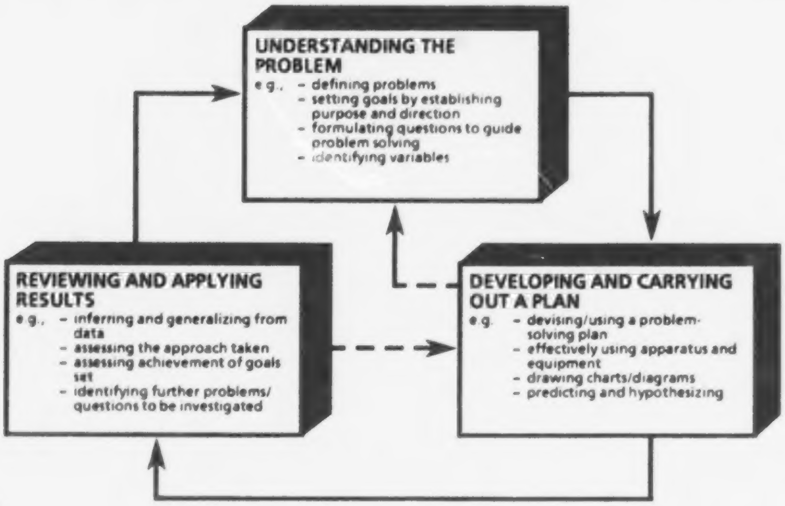
Many tasks performed at home and in the workplace rely upon the use of technological devices and systems. An understanding of familiar technologies, as well as the process by which they are developed, will assist students to use technology effectively in practical situations. This theme will enable students to:

- develop an understanding of scientific principles governing the operation of familiar technologies
- examine, test and evaluate simple devices and systems that are used at home and in the workplace
- design and construct a simple device that is intended to meet a specific need.

Particular attention should be placed on developing strategies for solving practical problems involving science and technology. A focus on problems that incorporate hands-on activities in their solution will foster active involvement in the problem-solving process. Teachers are encouraged to reference the "Program Emphases and Methodology" section of this manual when planning for instruction. Suggestions particularly relevant to the learning objectives addressed in this theme can be found in:

- "Science and Technology"
- "Communication Skills"
- "Assessment/Evaluation".

A FRAMEWORK FOR SOLVING PROBLEMS INVOLVING SCIENCE AND TECHNOLOGY


UNDERSTANDING THE PROBLEM
e.g., – defining problems
– setting goals by establishing purpose and direction
– formulating questions to guide problem solving
– identifying variables
DEVELOPING AND CARRYING OUT A PLAN
e.g. – devising/using a problem-solving plan
– effectively using apparatus and equipment
– drawing charts/diagrams
– predicting and hypothesizing
REVIEWING AND APPLYING RESULTS
e.g., – inferring and generalizing from data
– assessing the approach taken
– assessing achievement of goals set
– identifying further problems/questions to be investigated

CONCEPTS, SKILLS AND ATTITUDES

CONCEPTS

Students will be expected to demonstrate an understanding that:

- technology is the process of using scientific knowledge to solve practical problems and satisfy human needs/wants
  - identifies a variety of human needs/wants and the technological products and/or processes developed to meet them
  - illustrates, with at least one example, the application of scientific knowledge in solving a practical problem
- basic scientific principles are associated with the functioning of technological devices
  - identifies and explains relevant scientific facts, laws and theories related to two or more of the topics suggested below:
    - machines
    - electricity and/or electronics
    - heat and thermal systems
    - fluid systems
  - applies scientific principles that are investigated in explaining the operation of familiar technological devices
- many technological systems used at home and at work consist of combinations of subsystems that work together in accomplishing a particular task
  - gives examples of technological systems that consist of combinations of mechanical, electrical, thermal and/or fluid subsystems
  - identifies subsystems, component parts and energy flow within at least one technological system
- science can be used to advance technology and technology can be used to advance science
  - gives examples of situations where science leads to advances in technology
  - gives examples of situations where technology leads to advances in science
- new and emerging technological products/processes reflect current needs and wants in society
  - identifies a recent technology, the need it was intended to satisfy, and the process by which it was developed
- products of technology are often used by society before the full extent of benefits/problems resulting from their use can be known
  - infers the potential impacts of a recent technology on individuals and society.

SKILLS

Students will be expected to demonstrate an ability to:

- identify specific relationships that exist between science and current technologies
- observe and analyze the operation of familiar devices and systems, identifying component parts and scientific principles that are used
- prepare systems diagrams that illustrate how component parts and/or subsystems within a technological device work together to accomplish a task
- test and evaluate the performance of a familiar device
  - identifies basic principles governing its operation and use
  - infers potential malfunctions and appropriate maintenance/repair procedures
  - suggests ways to improve efficiency of design and/or operation
- design and construct a simple technological device or process
  - identifies a relevant need or problem not satisfied by technology
  - identifies alternative approaches/designs to deal with the problem
  - selects a design and constructs the device
  - tests and troubleshoots the device
  - evaluates the product and the process
- infer how specific technologies have personal application and solve practical problems.

ATTITUDES

Students will be encouraged to:

- display a positive attitude toward the learning of concepts and skills in science
  - shows interest and curiosity through willingness to ask questions, share observations and ideas, and seek answers
  - performs investigations and completes assignments independently and in cooperation with others
- appreciate the role of science and technology in serving human needs, and the usefulness of technological problem-solving skills in finding solutions to practical problems
- develop confidence in personal ability to understand and solve practical problems through the use of science and technology
- display a concern for safety when using technological devices and systems
- appreciate that ethical dilemmas may arise from the application of scientific research and/or technological developments
- appreciate the relationships among science, technology and society.

INTEGRATION ACTIVITIES

ENGLISH

Students will use a variety of communication skills throughout investigations in this theme. Activities in science will require students to:

- give and follow directions when planning/conducting investigations
- use comprehension skills when identifying patterns/relationships, predicting and hypothesizing
- use critical and creative thinking skills when designing, constructing and assessing a technological device or process.

Teachers are encouraged to identify appropriate strategies for developing these skills through cooperative conferencing with English teachers. Suggestions and ideas for developing related skills are also provided in the "Communication Skills" section of this manual.

MATHEMATICS

Students will use mathematical concepts and skills when they:

- measure distance, mass, time and temperature
- interpret statistical data involving rate, ratio and percent
- interpret and display data in table/chart/graph form
- use equations/formulas to describe scientific phenomena and relationships.

Science teachers are encouraged to confer with mathematics teachers in establishing relevant contexts and appropriate methodology for reinforcing the mathematical competencies that students will use throughout this theme.

SOCIAL STUDIES

Students will develop an awareness of the impacts of technological products and processes on life style and the environment through activities in current affairs. Cooperative planning between the science and social studies teachers may provide opportunities for students to:

- discuss/debate both the long-term and short-term effects of particular technologies
- identify economic, political and ethical perspectives that may influence developments in science and technology
- suggest strategies for resolving problems/issues in the local community that involve science and technology.

The study of warranties and guarantees in social studies may provide opportunities for students to focus attention upon the responsibilities of both consumer and manufacturer relative to the purchase and use of familiar technologies (e.g., hair dryers, cassette players).

OCCUPATIONAL COURSES

Students will likely use various mechanical, electrical, thermal and fluid technologies in their occupational courses. Cooperative conferencing among science and occupational teachers will assist in planning integrated activities that enable students to:

- investigate scientific principles that govern the operation of technologies used in occupational courses
- develop appropriate strategies for using/maintaining/repairing technologies in work-related situations.

COMMUNITY PARTNERSHIP OPPORTUNITIES

The local community may offer a variety of resources that contribute to the development of learning objectives within this theme. Suggestions for using these resources to develop an understanding of how science and technology are used in practical situations are provided below.

- Visit local business/industry and observe the use of technological products and processes (e.g., service station, restaurant, appliance repair shop, construction site).
- Invite a local mechanic, carpenter, electrician or other tradesperson to discuss basic scientific principles that govern the operation of the tools and equipment they use.
- Visit a local power generating plant and note energy transformation and applications of mechanical/electrical systems.
- Invite a representative from the local electrical company to discuss electrical distribution, consumption and technologies in the home.
- Invite a doctor/nurse/paramedic to discuss hazards inherent in the use of various technologies, and to identify related safety practices.
- Invite a representative from the Workers' Compensation Board to discuss safety checks and routines that are used to prevent accidental injury while using various technologies in the workplace.
- Invite a local MLA, alderman or councillor to discuss recent laws/regulations/debate with respect to the use of particular technologies.
- Arrange visits/interviews with scientists and engineers. Distinguish between the nature of the work performed by scientists and engineers. Discuss the contributions made by Canadian scientists and engineers in developing familiar technological products and processes.
- Interview several senior citizens. Ask them to describe ways in which society has changed over the last 30-50 years as a result of developments in science and technology.
- Ask students to make a list of the technological products/processes they use in performing routine activities on a given day. Encourage students to predict how future developments in science and technology may affect lifestyle.

RESOURCE CORRELATION

BASIC RESOURCE

ISIS Individualized Science Instructional System
Booklet: *Science, Technology, and You*

SUPPORT RESOURCES

Science at Work Series
Booklets: *Domestic Electricity*
Gears and Gearing

OTHER RESOURCES

ACME School of Stuff (video program)

Applied Science, Book 1
Unit 2 – Pressure in Fluids
Unit 4 – Machines Make Work Easier
Unit 12 – Electricity
Unit 13 – Electrical Appliances

Applied Science, Book 2
Unit 2 – Heavy and Light, Floating and Sinking
Unit 10 – Electronics: Our Modern Miracle

Principles of Science, Book 1
Chapter 4 – Work and Energy
Chapter 5 – Machines
Chapter 6 – Motion
Chapter 7 – Fluids and Pressure

Principles of Science, Book 2
Chapter 14 – Heat
Chapter 16 – Magnetism and Electricity

The Problem-Solving Film (video program)

Science at Work Series
Booklet: *Electronics*

Science Networks: Physical Science
Unit 3 – Heat
Unit 4 – Electricity

Simple Machines (video program)

SUGGESTED ACTIVITIES

The student learning resources identified above provide a variety of instructional activities that support learning objectives identified in this theme. The activities that follow complement those provided in the student learning resources. Teachers should be selective in their use, and consider students' interests/abilities and preferred methods of learning in planning appropriate instructional activities.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING OF TECHNOLOGY AS THE PROCESS OF USING SCIENTIFIC KNOWLEDGE TO SOLVE PRACTICAL PROBLEMS AND SATISFY HUMAN NEEDS/WANTS.

- **Identifies a variety of human needs/wants and the technological products and/or processes developed to meet them.**
- **Illustrates, with at least one example, the application of scientific knowledge in solving a practical problem.**

RESOURCE CORRELATION

BASIC RESOURCE

Science, Technology, and You
Chapter 1 – Technology and Society' Needs and Wants
Chapter 2 – Science, Technology, and Your Five Senses

1. Provide opportunities for students to consider ways in which their daily activities depend upon the use of technological products and/or processes. Construct log sheets and ask students to record how they use various technologies each day. Discuss and compare the logs that students complete.

CLARIFICATION/EXAMPLE

TIME	ACTIVITY	TECHNOLOGICAL PRODUCT/PROCESS
	wake up	clock radio
	shower	hot water heater
	breakfast	

Additional activities that will encourage students to appreciate how technological products/processes influence their daily activities are provided in the Science and Technology section of this manual:

- Resource 1: How Does Technology Affect Our Everyday Lives?
- Resource 2: How Frequently Do I Make Choices About Technology?

2. Identify and discuss familiar situations involving science (e.g., finding out how/why something "works"), and other situations involving technology (e.g., developing a product or process in order to solve a practical problem).

Sample activities that will help students to understand and distinguish between the processes of science and technology are provided in "Science and Technology":

- Resource 3: How Are Science and Technology Different?
- Resource 4: What Do Engineers and Scientists Do?

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING OF BASIC SCIENTIFIC PRINCIPLES ASSOCIATED WITH THE FUNCTIONING OF SIMPLE TECHNOLOGICAL DEVICES.

- **Identifies and explains relevant scientific facts, laws and theories related to two or more of the topics suggested below:**
  - **machines**
  - **electricity and/or electronics**
  - **heat and thermal systems**
  - **fluid systems.**
- **Applies scientific principles that are investigated in explaining the operation of familiar technological devices.**

RESOURCE CORRELATION

BASIC RESOURCE

Science, Technology, and You
Chapter 3 – The Scientific Process and Simple Machines
Chapter 4 – The Scientific Process and Electricity

SUPPORT RESOURCES

Domestic Electricity
Chapter 1 – Plugs and Sockets
Chapter 2 – Fuses
Chapter 3 – Household Lighting Circuits

Gears and Gearing

Teacher Resource Manual
Resource 1 – Electrical Distribution in the Home
Resource 2 – Electrical Safety

1. Assist students to design and conduct experiments that demonstrate basic principles governing the operation of machines/mechanical devices.

   e.g.,
   - friction/gravity/inertia
   - force/motion/work
   - transfer of energy
   - increase in speed
   - change in direction of force
   - multiplication of force

   Provide opportunities for students to examine the component parts of familiar machines/mechanical systems.

   e.g.,
   - common household gadgets (broom, bottle opener, knife, corkscrew)
   - familiar tools (screwdriver, wrench, wheelbarrow)
   - simple gear systems
   - mechanical systems (bicycle, sewing machine, building crane)

   Explain the operation of these devices through reference to scientific laws, facts and/or theories that have been investigated. Prepare systems diagrams that illustrate how component parts work together in accomplishing a task.

2. Assist students to design and conduct experiments that demonstrate basic principles governing the operation of electrical technologies.

   e.g.,
   - basic circuitry
   - electromagnetic principles
   - electrical resistance
   - conductors/insulators
   - short circuits

Provide opportunities for students to examine the component parts of familiar electrical devices.

e.g., – electrical toys and games
- door bells, chimes and buzzers
- electrical motors and generators
- electrical appliances (hair dryer, toaster, tea kettle)

Explain the operation of these devices through reference to scientific laws, facts and/or theories that have been investigated. Prepare systems diagrams that illustrate how component parts work together in accomplishing a task.

Focus attention on appropriate procedures/conditions for the safe operation of electrical devices at home and in the workplace. Discuss the use of fuses, circuit breakers and switches in protecting circuits against overload, and in permitting the repair of particular components within a system (see Resource 1: Electrical Safety).

3. Assist students to design and conduct experiments that demonstrate basic principles governing the operation of heat/thermal technologies.

e.g., – heat transmission (conduction, convection, radiation)
- conductors and conduction rates
- insulators
- temperature-volume relationships
- temperature-pressure relationships

Provide opportunities for students to examine the component parts of familiar thermal devices.

e.g., – thermostat
- vacuum bottle (thermos)
- cookware
- home heating system
- combustion engine

Explain the operation of these devices through reference to scientific laws, facts and/or theories that have been investigated. Prepare systems diagrams that illustrate how component parts work together in accomplishing a task.

4. Assist students to design and conduct experiments that demonstrate basic principles governing the operation of fluid technologies.

e.g., – nature of forces exerted by fluids
- buoyancy
- density
- pressure

Provide opportunities for students to examine the component parts of familiar fluid devices and systems.

e.g., – valves
- hydraulic/pneumatic systems
- pumping/plumbing systems

Explain the operation of these devices through reference to scientific laws, facts and/or theories that have been investigated. Prepare systems diagrams that illustrate how component parts work together in accomplishing a task.

5. Encourage students to develop an understanding of the relationship between science and technology through the investigations they conduct. Possible activities include:

   - naming a scientific concept, and asking students to identify a familiar technology that illustrates practical application of the concept
   - displaying pictures and/or models of familiar technologies, and asking students to explain the scientific concepts that govern the operation of each device.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING THAT MANY TECHNOLOGICAL SYSTEMS USED AT HOME AND AT WORK TOGETHER IN ACCOMPLISHING A PARTICULAR TASK.

- **Gives examples of technological systems that consist of combinations of mechanical, electrical, thermal and/or fluid subsystems.**
- **Identifies subsystems, component parts and energy flow within at least one technological system.**

RESOURCE CORRELATION

BASIC RESOURCE

Science, Technology, and You
Chapter 5 – Current Electricity, Servant of Technology

SUPPORT RESOURCES

Domestic Electricity
Chapter 4 – Household Power Circuits
Chapter 5 – Buzzers and Bells
Chapter 6 – Water Heaters

Teacher Resource Manual
Resource 3 – Technology in the Workplace

1. Ask students to bring old or non-functional appliances, tools, machines and toys to school for the purpose of assessing their usefulness and/or disrepair. Formulate questions about each device in order to structure and guide students in their observation and analysis of these technologies.

   e.g., – How does it work?
   – How do I use the device?
   – How can I maintain/repair it?
   – How can I improve the design of the device?

   As students investigate each device, ask questions that will focus attention on:

   - how its operation depends upon a combination of mechanical, electrical, thermal and/or fluid subsystems
   - how components/subsystems work together in accomplishing a particular task
   - feedback systems that may govern its operation.

2. Provide opportunities for students to investigate the technological devices/systems they use in their occupational courses (see Resource 2: Technology in the Workplace). Plan activities that will assist students to identify:

   - applications of mechanical, electrical, thermal and/or fluid subsystems in work-related technologies
   - appropriate strategies for troubleshooting and repairing simple malfunctions in the devices they use.

3. Visit a new home under construction. Ask an electrician to explain the function of various components of the "roughed-in" electrical system which is visible prior to drywall application.

   Once back in the classroom, ask students to analyze a portion of their home electrical system. Prepare models/diagrams that illustrate components within this system (see Resource 3: Electrical Distribution in the Home).

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING THAT SCIENCE CAN BE USED TO ADVANCE TECHNOLOGY AND TECHNOLOGY CAN BE USED TO ADVANCE SCIENCE.

- **Gives examples of situations where science leads to advances in technology.**
- **Gives examples of situations where technology leads to advances in science.**

RESOURCE CORRELATION

BASIC RESOURCE

Science, Technology, and You
Chapter 2 – Science, Technology and Your Five Senses

1. Gather media resources (e.g., newspapers, periodicals) that describe situations where:

   - scientific principles have contributed to the recent development of a technological product and/or process (e.g., fibre optics)
   - technological products and/or processes have been used to extend scientific knowledge (e.g., medical research).

   Sample activities that illustrate the interactions between science and technology are provided in Science and Technology, Resource 5: What is the Scientific Basis for Technology? and Resource 6: What is a Technological System?

2. Assist students to develop an understanding of how scientific knowledge is used in the technological problem-solving process through activities similar to those suggested in Science and Technology, Resource 7: How is a Technological Product Developed? and Resource 8: Can I Make a Better Paper Airplane?

   Provide opportunities for students to design and construct simple technologies that accomplish relevant tasks and/or solve practical problems. Encourage students to:

   - identify alternative designs/approaches to deal with problems that are identified
   - apply scientific principles to the solution of these problems
   - test and troubleshoot devices once they have been constructed
   - evaluate both the technologies and the problem-solving processes that are used.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING OF NEW AND EMERGING TECHNOLOGIES AS THEY RELATE TO PRACTICAL SITUATIONS.

- **Identifies a recent technology, the need it was intended to satisfy, and the process by which it was developed.**
- **Infers the impacts of this technology on individuals and society.**

RESOURCE CORRELATION

BASIC RESOURCE

Science, Technology, and You
Chapter 9 – Telecommunications: Advantages and Disadvantages

1. Ask students to conduct research on a recently developed technology, identifying:

   - problems/issues/needs that led to its development
   - the process by which it was developed
   - scientific principles that were used.

   Structure research activities using the suggestions provided in the Communication Skills section of this manual. Suggestions for evaluating student research are provided in Assessment/Evaluation, "Individual and Group Projects".

2. Provide opportunities for students to assess familiar technologies in terms of their impact on society.

   e.g., – Prepare a list of several technologies used at home or in work-related situations.
   – Infer the benefits and burdens of each technology to people and the environment.
   – Circle those technologies for which you feel the benefits outweigh the burdens.

   CLARIFICATION/EXAMPLE

TECHNOLOGICAL DEVICE	BENEFIT	BURDEN
robotics	(efficient industry)	(loss of jobs)
computers	(increased speed in calculations)	(health problems from video-display)
automobile	?	?
photocopier	?	?

   Encourage students to consider a variety of perspectives related to the use of familiar technologies by modelling strategies provided in Communication Skills, "Using Critical Thinking Skills".

   Use discussion and debate to help students recognize that:

   - it is possible to assess technological devices by the benefits and burdens they create
   - assessment depends on ability to predict both present and future consequences
   - compromises are often necessary in order to resolve issues involving science and technology in society.

3. Investigate the ways in which technological products and processes have affected current occupational opportunities. Sample activities that require students to examine changes in business, industry, career choices and employment brought about by science and technology are provided in Science, Technology and Societal Issues, "Resource 4: How Have Jobs and Careers Changed in the Last Thirty Years?" and "Resource 5: Where are the Jobs and Careers?"

RESOURCE 1: ELECTRICAL SAFETY

Electricity is a flow of electrons along a conductor. If a conductor is touched while electricity is flowing through it, an electrical shock may occur. Electricity is very useful, but can also be very dangerous if it not used in a safe manner.

SAFETY GUIDELINES

- Never touch wires carrying an electrical current if they are not insulated.
- Report all damaged or worn wiring to the teacher.
- Make immediate repairs to electrical cords having cut or damaged insulation.
- Use electrical cords with a ground wire whenever possible.
- Use only CSA approved electric cords, appliances and other devices.
- Know how to turn off the electricity in case of emergency.
- Never attempt repairs to an electrical device without first turning off the electrical supply.

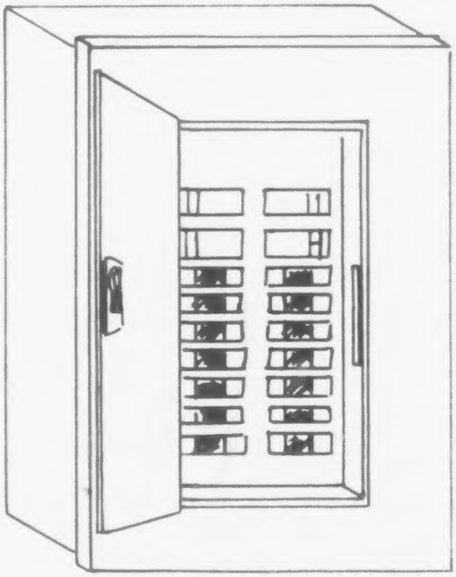
SAFETY COMPONENTS

Home-owners and workers should understand how certain components within an electrical system are used to control the flow of electricity through individual circuits. Three commonly used safety components are illustrated below.

1. Panelboards

   Panelboards control the supply of electricity in certain areas of a building or rooms in a house. Panelboards usually:

   - are enclosed in a cabinet
   - have breakers/switches for different areas and electrical functions in a building
   - have a master ON/OFF switch.



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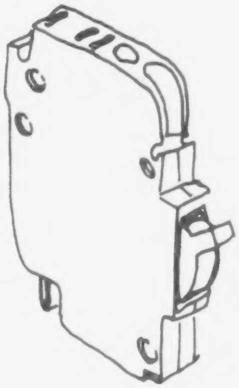
2. Breakers

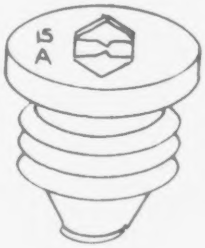
Breakers are switches on a panelboard. When a breaker is in the "ON" position, electricity is permitted to flow through a particular circuit. A breaker may be TRIPPED (returned to the "OFF" position) if a circuit becomes overloaded.



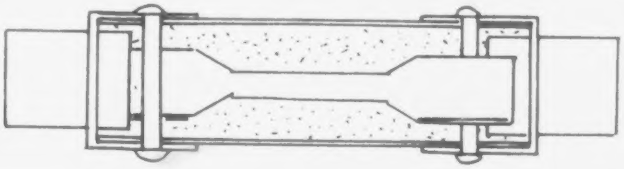
3. Fuses

Fuses are similar to breakers as they, too, protect a circuit from overloading. When too much electricity passes through a fuse it will burn out or break. Home owners and workers should understand how to locate and replace a burned-out fuse with a new fuse of the same type. Some of the more common types of fuses are illustrated below.

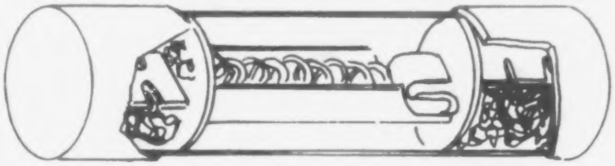
a. Non-renewable plug fuse (Edison screw base)



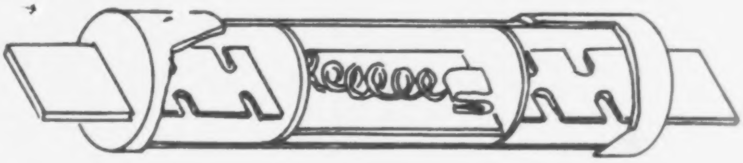
b. Non-renewable cartridge fuse with knife blade contacts



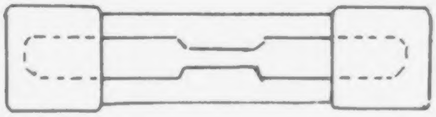
c. Non-renewable, dual-element time-delay cartridge fuse with ferrule contacts



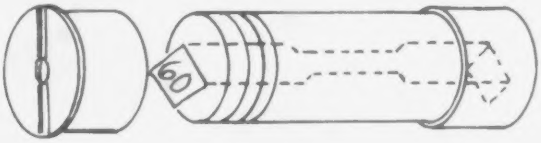
d. Renewable cartridge fuse with knife blade contacts



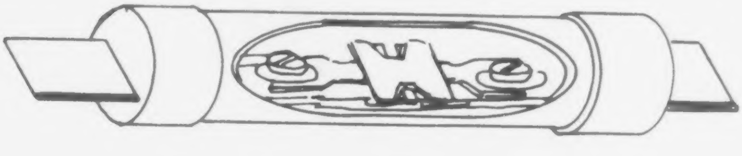
e. Non-renewable, miniature cartridge fuse for electronic applications



f. Renewable cartridge fuse with ferrule contacts



g. Renewable cartridge fuse with knife blade contacts.



RESOURCE 2: TECHNOLOGY IN THE WORKPLACE

An understanding of mechanical, electrical, thermal and fluid technologies will assist you in using appropriate tools and equipment in work-related situations.

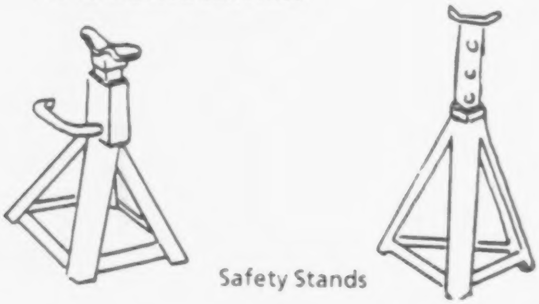
Select a technological device that you may use in one of your occupational courses. (Some technologies that are frequently used in work-related situations are illustrated below.) Investigate this device by:

- identifying scientific principles that govern its operation
- preparing a systems diagram that illustrates the functioning of component parts
- describing appropriate procedures for using the device
- identifying routine maintenance procedures
- inferring potential malfunctions and troubleshooting strategies.

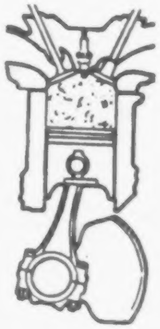
Report the results of your investigation to other members of your science class.

TOOLS/EQUIPMENT USED IN OCCUPATIONAL COURSES

AUTOMOTIVE SERVICES

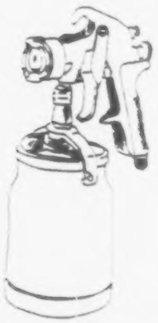


Safety Stands

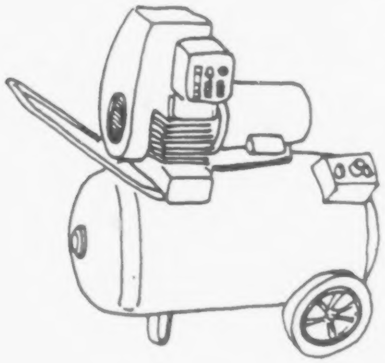


Combustion Engine

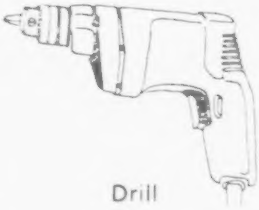
BUILDING SERVICES



Paint Spray Gun



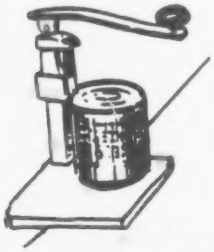
Air Compressor



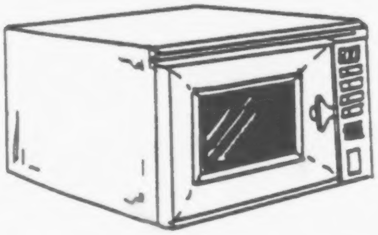
Drill

RESOURCE 2: TECHNOLOGY IN THE WORKPLACE (cont'd)

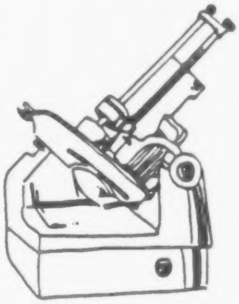
COMMERCIAL FOOD PREPARATION



Bench-Type Can Opener

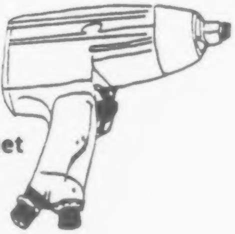


Microwave Oven

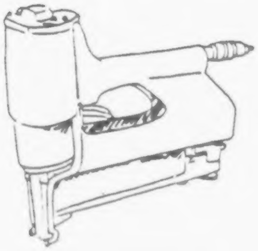


Slicer

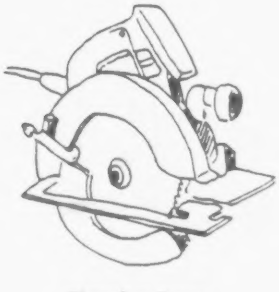
CONSTRUCTION SERVICES



Air Rachet

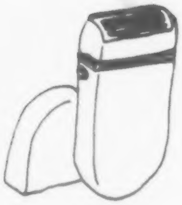


Pneumatic Stapler

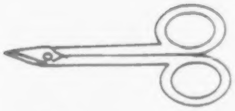


Circular Saw

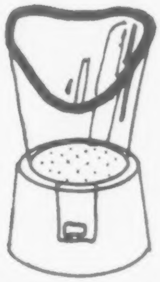
ESTHETOLOGY



Electric Razor



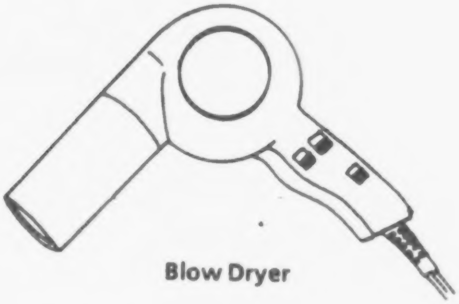
Scissors



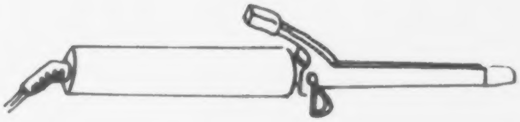
Facial Vaporizer

RESOURCE 2: TECHNOLOGY IN THE WORKPLACE (cont'd)

HAIR CARE

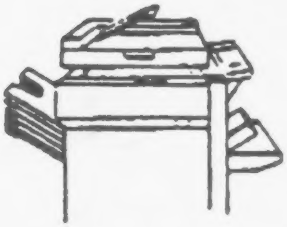


Blow Dryer

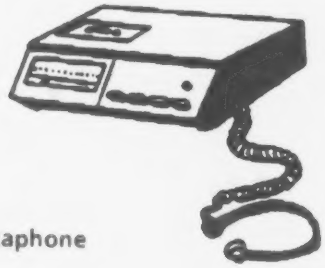


Curling Iron

OFFICE SERVICES

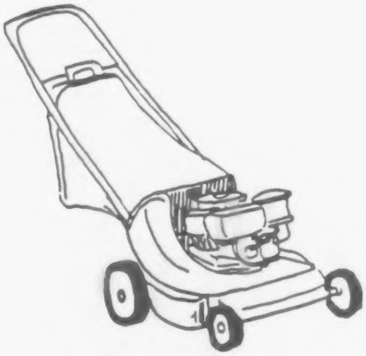


Photocopier

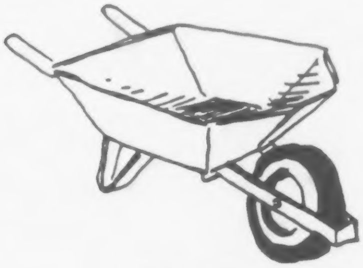


Dictaphone

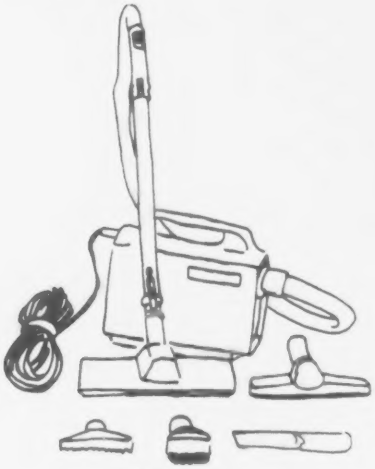
MAINTENANCE AND HOSPITALITY SERVICES



Lawn Mower



Wheel Barrow



Vacuum

RESOURCE 3: ELECTRICAL DISTRIBUTION IN THE HOME

Electricity is a widely used form of energy because it can be readily supplied to most locations. Electrical appliances and tools require little space and offer relatively trouble-free operation. Electrical utility companies ensure that homes and businesses have access to this form of energy.

Visit your local electrical utility company and ask a representative to explain:

- how electrical energy is produced for use in your community
- how electrical energy is distributed and consumed in your home.

STUDENT ACTIVITY

1. Draw a flow chart that illustrates how electricity is distributed from its source through various circuits in your home.

2. Explain the meaning of each of the following words as they relate to electrical distribution and/or consumption in the home.

   a. fuse

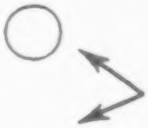
   b. circuit breaker

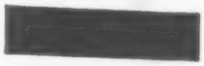
   c. electrical panel

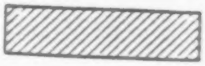
   d. kilowatt hour

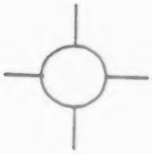
RESOURCE 3: ELECTRICAL DISTRIBUTION IN THE HOME (cont'd)

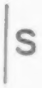
3. Use classroom or community resources to help you identify and explain the following symbols used in electrical drawings:

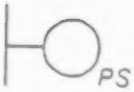


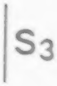


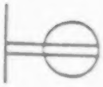


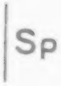


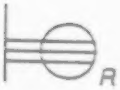


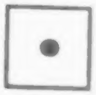


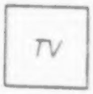


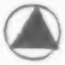


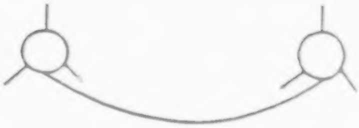


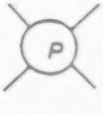












THEME D
MANAGING ENVIRONMENT AND RESOURCES

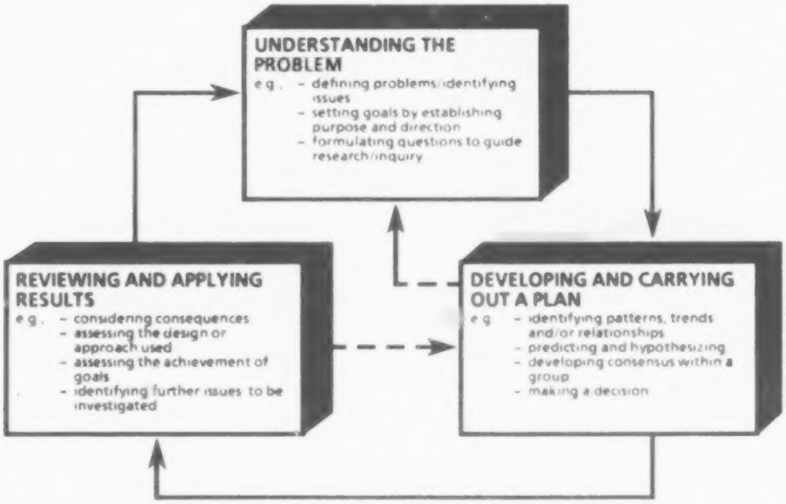
Human populations have had considerable impact upon the environment and our natural resources. As members of society, we must ensure that science and technology are used in ways that will minimize the impact of an increasing population on our fragile biosphere. This theme will enable students to:

- identify an environmental issue that arises from the local use of natural resources
- investigate the issue by considering a variety of related factors
- suggest an action plan to deal with the environmental issue.

Particular attention should be placed on developing a strategy for resolving societal issues that have a scientific or technological component. A focus on environmental issues in the local community will foster active involvement in the decision-making process. Teachers are encouraged to reference the "Program Emphases and Methodology" section of this manual when planning for instruction. Suggestions particularly relevant to the learning objectives addressed in this theme can be found in:

- "Science, Technology and Societal Issues"
- "Communication Skills"
- "Assessment/Evaluation".

A FRAMEWORK FOR EXAMINING ENVIRONMENTAL ISSUES


UNDERSTANDING THE PROBLEM
e.g. - defining problems/identifying issues
- setting goals by establishing purpose and direction
- formulating questions to guide research/inquiry
DEVELOPING AND CARRYING OUT A PLAN
e.g. - identifying patterns, trends and/or relationships
- predicting and hypothesizing
- developing consensus within a group
- making a decision
REVIEWING AND APPLYING RESULTS
e.g. - considering consequences
- assessing the design or approach used
- assessing the achievement of goals
- identifying further issues to be investigated

CONCEPTS, SKILLS AND ATTITUDES

CONCEPTS

Students will be expected to demonstrate an understanding that:

- the biosphere is a thin layer on the surface of the earth, able to support life
    - identifies components of the biosphere that provide the essentials of life
    - relates components of the biosphere to their importance in sustaining life
- a continuous supply of solar energy is essential to life
    - illustrates, with at least one example, how living things acquire their energy either directly or indirectly from the sun
    - explains how photosynthesis and respiration are involved in energy conversions necessary for life
    - traces energy transfer from one feeding level to another within a food pyramid, and describes how energy is lost at each transfer
- life depends upon recycling processes
    - illustrates, with at least one example, how biochemical cycles provide a continuous supply of materials necessary for life
    - explains how materials are decomposed through the recycling process
    - explains how biodegradable materials reduce the impact of man-made products on the environment
- living organisms interact with each other and with the physical environment
    - identifies physical factors that influence local populations
    - describes how interactions among organisms affect populations
    - illustrates, with at least one example, the impact of living organisms on the local environment
- individuals and society influence the quality of the environment
    - identifies familiar technological products and processes that produce materials that are not readily decomposed
    - gives at least one example of a local land-use practice resulting in major changes to the environment
    - describes the relationship between densely populated areas and the production of wastes that exceed the environment's capacity to recycle
    - gives examples of how technological developments and societal actions may improve the quality of the local environment
- developments in science and technology may have unforeseen consequences on society and the environment
    - gives examples of how science and technology develop in response to societal needs
    - explains how scientific/technological developments, while meeting human wants and needs, may create or intensify environmental problems (e.g., pollution)

  - identifies examples of the unforeseen consequences of science and technology in the local area
  - evaluates the societal impact of at least one development in science and technology

- individuals and society can become involved in the resolution of ecological problems that arise

  - identifies ways in which an individual can provide a degree of direction and control over local use of environment and resources (e.g., personal habits, lobby groups)
  - identifies ways that society can influence science/technology in resolving ecological problems (e.g., voting, legislation, provision of fiscal and manpower resources).

SKILLS

Students will be expected to demonstrate an ability to:

- identify an environmental issue related to the local use of natural resources

- gather information related to the issue through observation, interview and/or research

- design experiments, through class discussion, that illustrate how particular practices or products are related to the issue and influence environmental quality

- analyze and assess information by identifying patterns and relationships, by judging the reliability/validity of information gathered and by considering consequences

- communicate the results of investigation verbally, through the use of models and diagrams, and/or through written expression

- take an informed position on the issue, identifying strategies that may be used to deal with the situation.

ATTITUDES

Students will be encouraged to:

- display a positive attitude toward the learning of concepts and skills in science

  - shows interest and curiosity through willingness to ask questions, share observations and ideas, and seek answers
  - performs investigations and completes assignments independently and in cooperation with others

- appreciate the fragility of the biosphere

- appreciate the interdependence of self with other living forms and the environment

- appreciate that environmental issues involve significant relationships among science, technology and society

- realize our inability to anticipate the environmental effects of human activities

- appreciate that the collective action of individuals can have significant impact

- develop a sense of personal responsibility in relation to environmental issues.

INTEGRATION ACTIVITIES

ENGLISH

Students will use a variety of communication skills throughout investigations in this theme. Activities in science class will require students to use:

- comprehension skills when gathering and interpreting data about the use of environment and resources
- reporting and note-taking skills when recording and organizing the information they gather
- inquiry skills when assessing the impact of human practices on the environment.

Teachers are encouraged to discuss strategies that foster the development of these skills with English teachers. Strategies for developing communication skills in science are also provided in the "Communication Skills" section of this manual. Learning activities that develop an awareness of interrelationships among science, technology and society may involve research and writing activities that can be integrated with the English program.

MATHEMATICS

Students will use mathematical concepts and skills when gathering, interpreting and displaying data. Mathematical concepts and skills used by students in science class may include:

- measuring mass, capacity and temperature
- interpreting and displaying data in tables, charts and graphs
- interpreting statistical data expressed as ratio or percent
- calculating measures of central tendency.

Cooperative planning will provide opportunities for students to apply mathematical skills in a scientific context. Data obtained in science class can be organized and analyzed in mathematics class.

SOCIAL STUDIES

Students will increase their knowledge and awareness of current environmental issues through activities in current affairs. Investigations might focus attention on:

- impacts on science and technology on local populations and the environment
- alternative strategies for resolving local environmental issues.

The study of politics in social studies will provide additional opportunities for students to recognize their potential to influence and resolve environmental issues through the democratic process.

OCCUPATIONAL COURSES

Students will develop an awareness of the need for environmental controls in the workplace, and will consider both short- and long-term effects of sanitation procedures on others and the environment. Science teachers are encouraged to confer with occupational teachers in planning activities that will enable students to develop appropriate strategies for:

- storing, disposing of and recycling waste materials used in the home, community and workplace
- minimizing the environmental impact of materials and procedures used in producing a product or providing a service.

COMMUNITY PARTNERSHIP OPPORTUNITIES

The local community may offer a variety of resources that contribute to the development of learning objectives within this theme. Suggestions for using these resources, and for developing an understanding of environmental issues through situational and concrete learning experiences in the community are provided below.

- Visit a wildlife officer, agriculturalist, forestry official or environmentalist to discuss concerns related to local use of the environment.
- Identify environmental issues of local significance in newspapers and magazines. Conduct further investigation of these issues by:
  - interviewing local citizens/industries that are directly involved with the issues
  - contacting government agencies
  - conducting library research.
- Interview a long-time local resident who can describe ways in which the local environment has changed during the last 20-50 years.
- Observe land erosion by taking a field trip to an eroded area or an erosion prevention project.
- Interview local officials responsible for water quality, noise control and/or disposal of solid wastes.
- Visit local facilities used for water purification, sewage treatment and/or waste disposal.
- Investigate recycling initiatives in the local community. Identify materials that are presently recycled and others that may be recycled in the future. Visit a recycling plant.
- Invite local aldermen, councillors or MLA's to discuss current policy and debate relating to pollution and environmental quality.
- Invite a representative from the local electrical or natural gas utility company to discuss energy conservation in the home.
- Visit a solar efficient building or a local facility that harnesses wind energy. Discuss energy conservation as it relates to the use of these technologies.
- Visit local companies involved in extracting, refining or using fossil fuels. Investigate the effects of these processes on the environment.
- Obtain media resources (e.g., pamphlets, films, videos) on environmental issues by contacting local and provincial government agencies.

RESOURCE CORRELATION

BASIC RESOURCE

ISIS Individualized Science Instructional System
Booklet: *Investigating the Environment*

SUPPORT RESOURCE

Science at Work Series
Booklet: *Pollution*

OTHER RESOURCES

Applied Science, Book 1
Unit 9 – The World We Live In

Farewell, Ancient Mariner (video program)

Greenhouse Effect (video program)

Principles of Science, Book 1
Chapter 18 – Populations and Communities
Chapter 19 – Food and Energy
Chapter 22 – Soil, Water and Air Conservation
Chapter 23 – Forest and Wildlife Conservation

Principles of Science, Book 2
Chapter 22 – People and Resources
Chapter 23 – People and Their Environment

Science Networks: Biology
Unit 7 – Ecology

Science Networks: Physical Science
Unit 6 – Wise Use of Energy

SUGGESTED ACTIVITIES

The student learning resources identified above provide a variety of instructional activities that support learning objectives identified in this theme. The activities that follow complement those provided in the student learning resources. Teachers should be selective in their use, and consider students' interests/abilities and preferred methods of learning in planning appropriate instructional activities.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING THAT THE BIOSPHERE IS A THIN LAYER ON THE SURFACE OF THE EARTH, ABLE TO SUPPORT LIFE.

- **Identifies components of the biosphere that provide the essentials of life.**
- **Relates components of the biosphere to their importance in sustaining life.**

RESOURCE CORRELATION

BASIC RESOURCE

Investigating the Environment
Chapter 3 – Meet the Biosphere

1. Identify and discuss components of the biosphere and interactions that occur among these components. Encourage students to infer the effects of abiotic components of the biosphere on living organisms in the local community. (e.g., Predict what might happen to local plants and animals if particular components of the biosphere become contaminated.)

   Assist students to generate ideas about possible relationships and to make predictions using suggestions provided in Nature of Science, "Proposing Ideas".

2. Ask students (individually or in groups) to locate an area close to the school where a variety of living organisms can be found.

   e.g., – a square metre of lawn
   – the earth under a log
   – a weed patch in a nearby field
   – the edge of a stream
   – a densely wooded area

   Mark the area off and observe all life forms and interactions present. Record the following data with respect to observations that are made.

   - date and time of observation
   - location
   - size of area
   - principal growth
   - plant and animal census
   - temperature
   - sunlight
   - soil conditions.

   Draw a map that shows the location of all living organisms included in the census. Identify non-living elements that have influenced the distribution of plants and animals within this area.

3. Visit a pond and mark a path from the pond through a field into a wooded area. At two-foot intervals, randomly toss a hoop and take a sample of plant life. Label each sample with its distance from the pond. Continue taking samples up to twenty feet into the wooded area. Mount the samples on poster paper to illustrate the direction of the path. Observe a plant from each sample and note differences among the plants along the path. Identify abiotic factors along the path that may have affected plant growth. Hypothesize the effects of these abiotic factors on living organisms in the area.

4. Compile a glossary of ecological terms. Provide examples and illustrations of each term through observations made in the local environment.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING THAT A CONTINUOUS SUPPLY OF SOLAR ENERGY IS ESSENTIAL TO LIFE.

- **Illustrates, with at least one example, how living things acquire their energy either directly or indirectly from the sun.**
- **Explains how photosynthesis and respiration are involved in energy conversions necessary for life.**
- **Traces energy transfer from one feeding level to another within a food pyramid, and describes how energy is lost at each transfer.**

RESOURCE CORRELATION

BASIC RESOURCE

Investigating the Environment
Chapter 4 – Sun Energy: Who Needs It
Chapter 5 – Food Webs, Pyramids, and Energy

1. Ask students to predict what might happen if:

   - the sun were suddenly "shut off"
   - the sun began to give off more/less energy
   - the earth began to move closer to/further away from the sun.

   Suggestions that may help students to predict and hypothesize are provided in Nature of Science, "Useful Strategies and Skills".

2. Investigate the conversion of light energy to food through the process of photosynthesis. Discuss the following statement:

   "Plants store the sun's energy."

3. About one-half of the sun's energy that strikes the top of atmosphere reaches the surface of the earth. Investigate what happens to the solar energy that reaches the surface of the earth.

4. Writes a science fiction composition entitled "The Sun Stopped Shining". Use the pre-writing strategies provided in Communication Skills, "Summarizing, Evaluating and Communicating Ideas in Science".

5. Investigate local food chains. Illustrate how a number of food chains can intermesh to form a food web. Draw diagrams or make posters to depict the interrelationships discovered.

   Ask questions that will encourage students to apply knowledge gained in determining cause and effect relationships and in making predictions.

   e.g., – What happens to a food chain/web when one member becomes over-abundant or scarce?
   – How do chemical and physical factors affect food chains?
   – What factors may affect the size of a given population?
   – What is the basic source of energy for all members of a food chain/web?

   Describe a simple three-step or four-step food pyramid. Determine where the energy originates, and what happens to the energy at each level in the pyramid. Draw and label a diagram of the energy cycle.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING THAT LIFE DEPENDS UPON RECYCLING PROCESSES.

- **Illustrates, with at least one example, how biochemical cycles provide a continuous supply of materials necessary for life.**
- **Explains how materials are decomposed through the recycling process.**
- **Explains how biodegradable materials reduce the impact of man-made products on the environment.**

RESOURCE CORRELATION

BASIC RESOURCE

Investigating the Environment
Chapter 6 – Cycles and Recycling

1. Draw diagrams that illustrate how particular biochemical cycles provide a continuous supply of materials that are essential to the survival of plants and animals.

   e.g., – oxygen cycle
   – carbon cycle
   – water cycle

2. Conduct investigations that illustrate how biodegradable materials are decomposed through recycling processes.

   e.g., – What role is played by "decomposers" in a forest community?
   – How does a piece of bread decompose?

3. Distinguish between "biodegradable" and "non-biodegradable" materials. Provide opportunities for students to:

   - identify materials of each type
   - compare and contrast the process of decomposition in each type of material.

   Collect samples of biodegradable and non-biodegradable materials frequently used and disposed of at home and in the workplace. Make a collage/bulletin board display using samples of each type of material.

4. Conduct a class discussion/debate on the following topic:

   "The pros and cons of using 'disposable' products."

   Throughout discussion and debate, ask questions that will encourage students to:

   - recognize the value of biodegradable materials in our "throw away" society
   - consider alternatives that may reduce the impact of the materials we use on the environment.

   Structure discussion and debate using suggestions provided in Communication Skills, "Strategies for Discussing and Debating".

5. Ask students to research recent developments in "biotechnology". Investigate how the processes/products of biotechnology are used in manufacturing consumer items that are biodegradable.

   Structure research activities using strategies provided in Communication Skills, "Reading and Viewing Science Materials".

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING OF HOW LIVING ORGANISMS IN THE LOCAL ENVIRONMENT INTERACT WITH EACH OTHER AND WITH THE PHYSICAL ENVIRONMENT.

- **Identifies physical factors that influence local populations.**
- **Describes how interactions among organisms affect populations.**
- **Illustrates with at least one example the impact of living organisms on the local environment.**

RESOURCE CORRELATION

BASIC RESOURCE

Investigating the Environment
Chapter 7 – Ecosystems and Populations

1. Discuss the following statement:

   > "When one part of the natural environment is altered or changed, other biotic/abiotic parts are also affected."

   Identify ways in which human activities have altered and changed the local environment, and infer the effects of these changes on plants and animals. Structure discussion using guidelines provided in Communication Skills, "Strategies for Discussing and Debating".

   Interview a long-time resident who can describe ways in which the local environment has changed over the last 20-50 years. Collect pictures and newspaper reports that provide evidence of some of these changes.

2. Imagine that a lake has become poisoned through the disposal of untreated wastes. Explain why the balance between living and non-living elements in this environment may be affected.

3. Research the effects of the spruce budworm upon the spruce tree population. Infer how changes in the spruce tree population may affect other biotic and abiotic factors present in the environment.

4. Draw and label a food chain for several different carnivores and herbivores living in your area. Identify producers, primary consumers and secondary consumers within each chain. Draw a food web that includes these food chains.

5. Draw a three-level food pyramid. Discuss what might happen to the food pyramid if fire destroys the bottom portion. Draw a new pyramid to illustrate the outcome.

6. Discuss the meanings of the following words as they relate to plants, animals and interactions within the local environment:

   - adaptation
   - competition
   - predation
   - producer
   - consumer
   - decomposer.

   Vocabulary development strategies are provided in Communication Skills, "Developing Technical Vocabulary".

7. Collect wildlife pictures from magazines. Classify the organisms illustrated in these pictures as producers, primary consumers/secondary consumers, parasites, scavengers and/or decomposers.

8. Describe three stages of succession that may occur in the local environment over the next ten years. Predict changes in local vegetation, and how these changes may affect other biotic and abiotic elements in the environment.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING OF HOW INDIVIDUALS AND SOCIETY INFLUENCE THE QUALITY OF THE ENVIRONMENT.

- **Identifies familiar technological products and processes that produce materials that are not readily decomposed.**
- **Gives at least one example of a local land-use practice resulting in major changes to the environment.**
- **Describes the relationship between densely populated areas and the production of wastes that exceed the environment's capacity to recycle.**
- **Gives examples of how technological developments and societal actions may improve the quality of the local environment.**

RESOURCE CORRELATION

BASIC RESOURCE

Investigating the Environment
Chapter 1 – Telephones and Trash

SUPPORT RESOURCES

Pollution
Chapter 1 – What is Pollution?
Chapter 2 – Litter
Chapter 3 – Water Pollution
Chapter 4 – Air Pollution

Teacher Resource Manual
Resource 1: Will No-Till Planting Be Accepted as a Farming Practice?

1. Identify various sources of pollution in the local community. Classify the pollutants according to their effect on the environment.

   e.g.,

   Air Pollution
   smoking
   biocides
   nuclear testing
   automobile exhaust

   Water Pollution
   acid rain
   industrial run-off
   chemical disposal
   sewage

   Soil Pollution
   acid rain
   garbage/litter
   biocides
   industrial refuse

   Noise Pollution
   industrial machines
   stereos
   aircraft
   vehicles/boats/motor cycles

2. Ask students to design and conduct simple experiments that monitor local pollution factors.

   e.g., – Coat several slides with petroleum jelly. Place the slides in different outdoor locations for several days. Examine the slides under a microscope and note air pollutants that have collected on the petroleum jelly.

   – Gather different water samples (e.g., rainwater, well water, water from a local stream/lake/river). Compare the acidity of water samples by measuring pH level.

   Guidelines that may help students to plan and structure their investigations are provided in Nature of Science, "Useful Strategies and Skills".

3. Investigate noise pollution in the local area. Record in a chart the information that is gathered, describing:

   - sources of noise pollution
   - the effects of noise pollution on personal health and the environment
   - local bylaws/regulations intended to control noise pollution
   - alternative strategies that may be effective in reducing noise pollution.

4. Identify biocides that may be used in the local community. Evaluate the use of these biocides by considering their long-term and short-term effects on the environment. Guide students through the process of critical thought, using strategies provided in Communication Skills, "Using Critical Thinking Skills".

   Collect media reports of environmental/health problems associated with the use of biocides. Identify alternatives to the use of biocides in controlling pests. Provide opportunity for students to conduct a debate:

   > "Natural methods of controlling plant pests versus chemical methods of controlling plant pests".

   Structure debate, using the guidelines provided in Communication Skills, "Strategies for Discussing and Debating".

5. Evaluate local methods of waste disposal by considering their effect on biotic/abiotic parts of the local environment.

   e.g., – open dumping
   – incineration
   – sanitary landfill
   – salvage
   – pulverization/compaction

   Identify alternative strategies for disposing of solid wastes that may reduce the environmental impact of methods currently being used.

   Investigate the disposal of toxic waste materials. Collect and discuss media reports on issues associated with the disposal of toxic wastes. Does your community have a system for disposing of toxic wastes?

6. Identify problems and formulate questions related to an environmental issue of local significance.

   e.g., – the development/practices of a local industry
   - the development of a recreational facility in a wilderness area
   - local methods of sewage disposal
   - deforestation in a local area
   - local farming/land-use practices

   Gather information on the issue by interviewing local residents, and by contacting community and provincial government agencies (e.g., Alberta Environment). Discuss both long-term and short-term effects of the development/practice on the quality of the local environment.

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING THAT DEVELOPMENTS IN SCIENCE AND TECHNOLOGY MAY HAVE UNFORESEEN CONSEQUENCES ON SOCIETY AND THE ENVIRONMENT.

- **Gives examples of how science and technology develop in response to societal needs.**
- **Explains how scientific/technological developments, while meeting human wants and needs, may create or intensify environmental problems (e.g., pollution).**
- **Identifies examples of the unforeseen consequences of science and technology in the local area.**
- **Evaluates the societal impact of at least one development in science and technology.**

RESOURCE CORRELATION

BASIC RESOURCE

Investigating the Environment
Chapter 2 – Environments and Values

SUPPORT RESOURCES

Pollution
Chapter 2 – Litter
Chapter 3 – Water Pollution
Chapter 4 – Air Pollution

Teacher Resource Manual
Resource 2: Will We Be Sorry Tomorrow for the Technology We Have Used Today?
Resource 3: Environmental Issues

1. Products of science and technology are often accepted and used by society before the full extent of benefits/problems resulting from their use can be fully known. Identify environmental problems/issues of both local and global significance that have been caused by developments in science and technology. Formulate questions related to the problems/issues that are identified, and consider alternative courses of action for dealing with these issues.

   e.g., – acid rain
   - radioactive fallout
   - destruction of the ozone layer
   - greenhouse effect
   - predator extermination programs
   - urban development
   - use of biocides
   - oil spills

   Activities that may assist students to recognize relationships between science/technology and societal issues have been provided in Science, Technology and Societal Issues, "Interactions Among Science, Technology and Society".

2. Research the development of a resource within the local community (e.g., hydro-electric plant, coal mine, petroleum recovery project). Use several different strategies to gather information about the project.

   e.g., – interviews/guest speakers
   – field trips
   – surveys
   – semantic webs/flow charts

   Evaluate the development of this resource by considering its effects on:

   - physical parts of the environment
   - local plant and animal populations
   - human populations.

3. Invite a wildlife officer or biologist to explain how our use of natural resources may upset ecological balance and cause:

   - cyclic phenomena in wildlife
   - certain species to become endangered.

4. Ask students to discuss the following statement:

   > "Many laws have been established that make it illegal to hunt certain animals due to the season or threat of extinction. Yet humans frequently destroy the habitats of animals and upset balance in the ecosystem when they build new roads and recreational facilities in wilderness areas."

   Structure discussion using strategies provided in Communication Skills "Strategies for Discussing and Debating".

LEARNING OBJECTIVE

DEMONSTRATES AN UNDERSTANDING THAT INDIVIDUALS AND SOCIETY CAN BECOME INVOLVED IN THE RESOLUTION OF ECOLOGICAL PROBLEMS THAT ARISE.

- **Identifies ways that an individual can provide a degree of direction and control over local use of environment and resources (e.g., personal habits, lobby groups).**
- **Identifies ways that society can influence science/technology in resolving ecological problems (e.g., voting, legislation, provision of fiscal and manpower resources).**

RESOURCE CORRELATION

BASIC RESOURCE

Investigating the Environment
Chapter 8 – Environments: For Better or for Worse

SUPPORT RESOURCE

Teacher Resource Manual
Resource 4: What is in an Aerosol Spray?

1. Plan activities that will enable students to recognize that although many of today's environmental problems have been caused by developments in science and technology, solutions to these problems are also provided through scientific research and technological development.

e.g., – methods for disposing of hazardous wastes
- emission control systems for automobiles and industry
- scientific management of wildlife
- the development of alternative sources of energy

Prompt students to consider relationships between science, technology and environmental quality through activities similar to those provided in:

- Resource 1: Will No-Till Planting Be Accepted as a Farming Practice?
- Resource 2: Will We Be Sorry Tomorrow for the Technology We Have Used Today?
- Resource 4: What is in an Aerosol Spray?

2. Discuss the value of "recycling" in conserving natural resources and maintaining environmental quality. Identify materials suited to recycling (e.g., paper, glass, metal), as well as strategies for collecting and recycling these materials.

   Investigate recycling programs that exist in the local community. Encourage students to:

   - formulate plans for a recycling project
   - explain how the project may conserve natural resources and improve environmental quality
   - identify related entrepreneurial opportunities.

3. Discuss ways in which individuals can exercise a degree of direction and control over environmental issues through political and/or consumer actions.

   e.g., – Find out what steps are involved in changing legislation and by-laws in your community.
   - Interview a political candidate in your community and determine what their intentions are concerning environmental issues.
   - Write a letter to your Member of Parliament expressing your concerns related to an environmental issue faced by your community.
   - What consumer actions might control the manufacture of products hazardous to the environment?
   - Brainstorm other ways in which individuals can support the betterment of both local and global environments.

4. Ask students to express their point of view on an environmental issue through an informal writing project. The project might focus attention on ability to:

   - elaborate on an opinion/point of view
   - provide detail that supports a point of view.

   Suggestions for writing and evaluating informal essays are provided in Communication Skills, "Informal Essay Writing".

5. Obtain a copy of *The Alberta Environmental Directory, Third Edition*, 1989. This publication provides information about environmental agencies, services and initiatives in Alberta (e.g., address and contact information; details of the nature of the organization – its structure, purpose and major environmental activities). The directory can be obtained by contacting:

   Alberta Environment Directory Orders
   c/o The Pembina Institute
   Box 7558
   Drayton Valley, Alberta
   T0E 0M0
   Telephone: 542-6272.

RESOURCE 1: WILL NO-TILL PLANTING BE ACCEPTED AS A FARMING PRACTICE?

PURPOSE

To show that acceptance of a technological process depends on the attitudes of individuals or societies toward it.

INTRODUCTION

Conventional plowing methods have contributed to the loss of half of the nation's topsoil during this past century, and the loss is growing. Conventional plowing produces "clean" fields and good weed control.

Recently, no-till planting, or planting without turning over the soil, has challenged old methods. The advantages of no-till planting include:

- Wind and water erosion are reduced when the previous season's crops remain in place.
- Less fuel is used in growing crops because both planting and herbicide application are done in just one trip over the field.
- Decreased evaporation increases the amount of water in the soil that can be used by the crop.
- Winter ground cover provides protection to wildlife.

PROCEDURE

A. Interview farmers, conservationists, and environmentalists in your area and report your findings on no-till planting.

Some sample questions which you might ask include:

1. Is no-till planting better than conventional methods? Why?
2. What are the disadvantages, if any, of no-till planting?
3. Why do some farmers oppose no-till planting?
4. Should we influence farmers to start no-till planting?
5. How important is the conservation of topsoil?
6. Do the benefits from no-till planting outweigh the burden of herbicide dangers?

B. Discuss in class the views of farmers, conservationists, and environmentalists about no-till planting. What are your views? Why are these your views?

C. Conduct a survey among farmers to determine how widely accepted no-till planting has become.

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RESOURCE 2: WILL WE BE SORRY TOMORROW FOR THE TECHNOLOGY WE HAVE USED TODAY?

PURPOSE

To show that some technological processes and devices have been used for their short-term benefits without attention to their long-term burdens.

PROCEDURE

List the short-term benefits and long-term burdens of each of the following technological processes or devices.

RESULTS

Indicated in parentheses. A valuable reference for information about the short-term benefits and long-term burdens of technological processes or devices is John W. Hill, *Chemistry for Changing Times* (Burgess Publishing Co., Minneapolis, MN, 1980).

DATA TABLE

Technological Process or Device	Short-term Benefit	Long-term Burden
nuclear energy	(electricity)	(radioactive waste)
chemical fertilizers	(higher agricultural yields)	(eutrophication of lakes)
insecticides	(higher agricultural yields)	(extinction of helpful species while target pests acquire immunity; contamination of water supplies)
artificial sweeteners	(convenience for diabetics and dieters)	(possible increased risk of cancer)
strip mining	(increased fuel supply)	(unusable land; water pollution)
nitrites	(prevention of botulism)	(increased risk of cancer)
automobile	(increased mobility)	(increased air pollution)
modern-day packaging with synthetic materials	(fresher food)	(nonbiodegradable waste in landfills)
radioactive isotopes	(cancer treatment)	(increased risk of other cancer)
logging	(increased supply of wood products)	(deforestation of tropical jungles)

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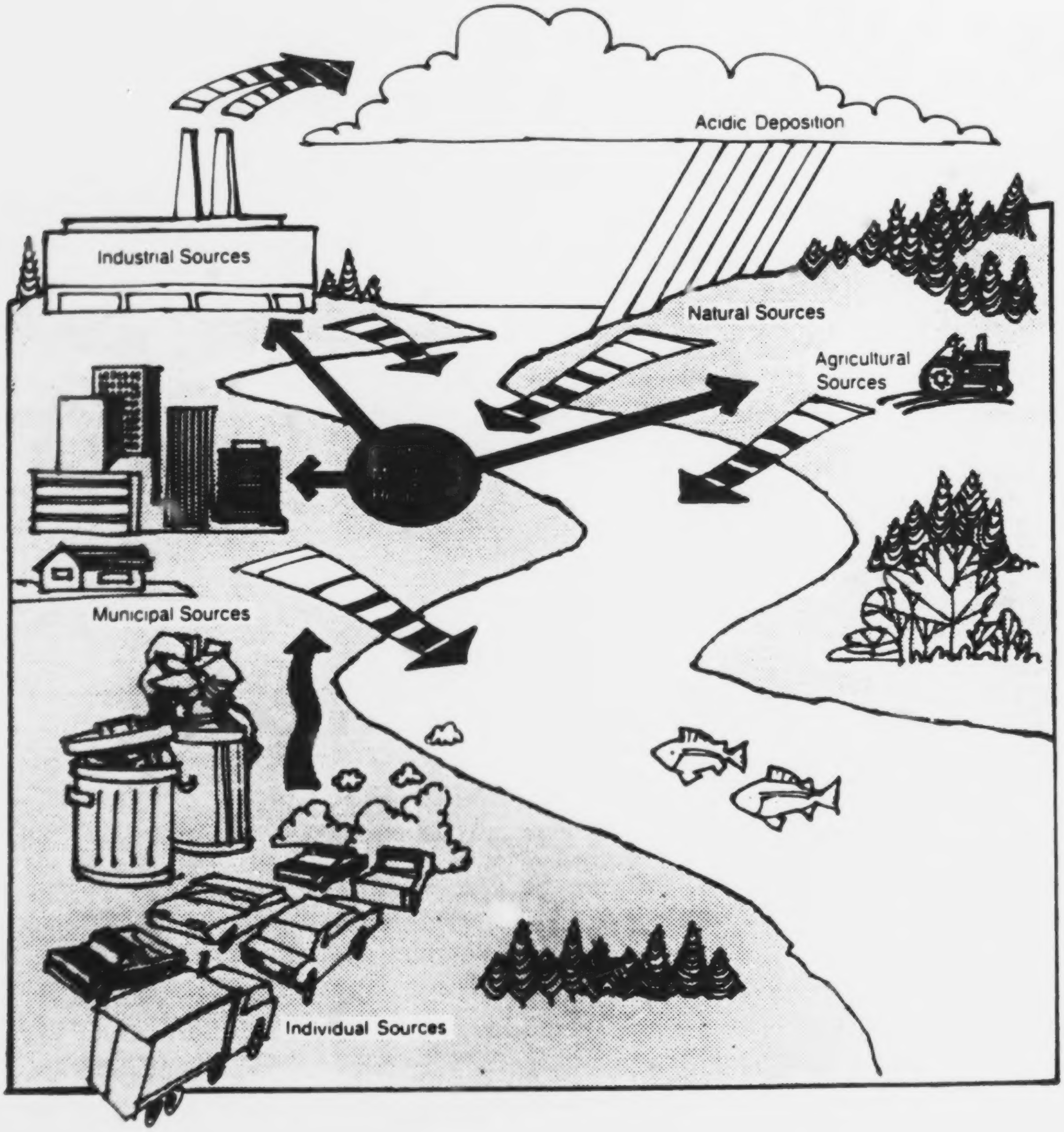
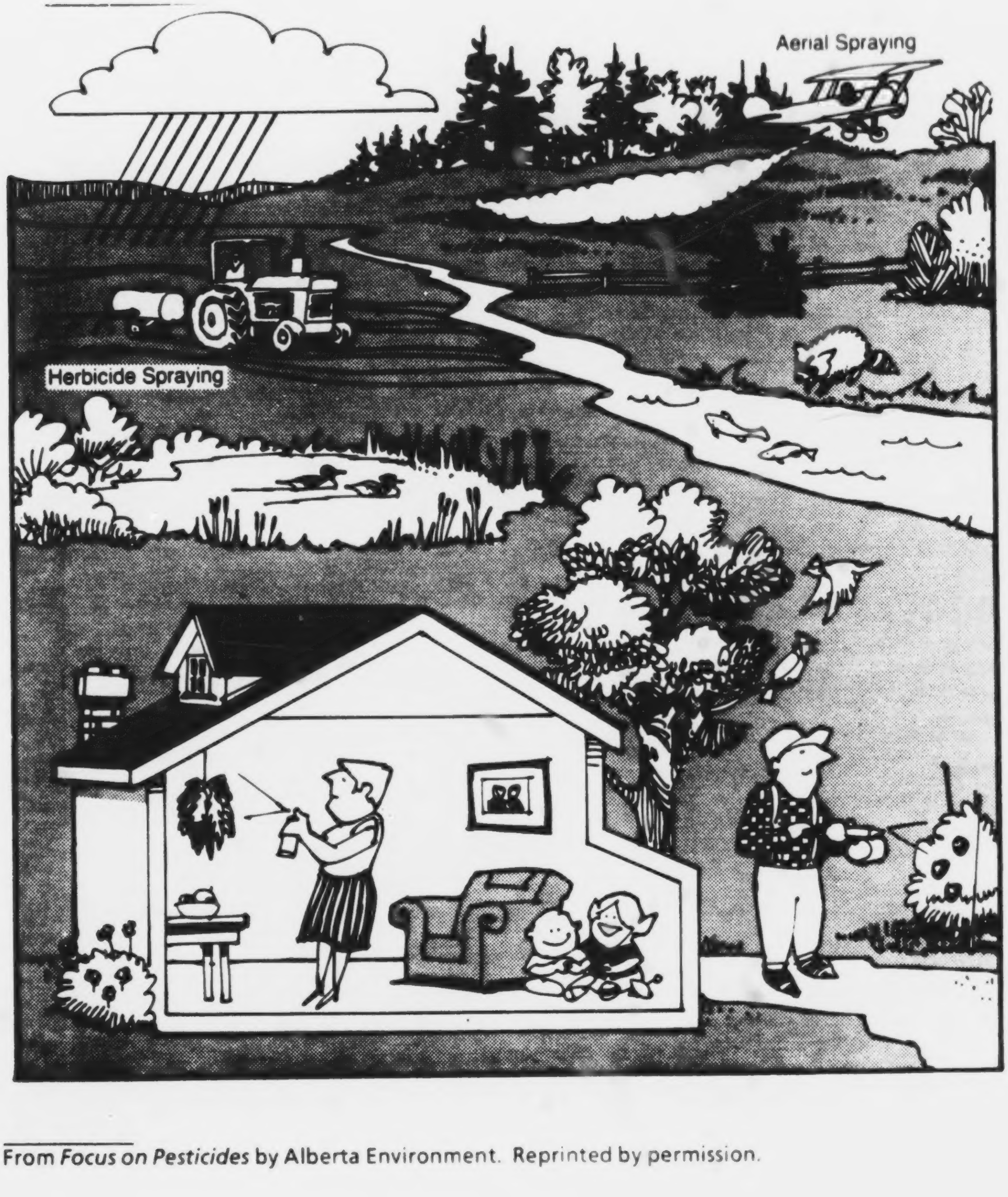
RESOURCE 3: ENVIRONMENTAL ISSUES

POLLUTION


Acidic Deposition
Industrial Sources
Natural Sources
Agricultural Sources
Municipal Sources
Individual Sources

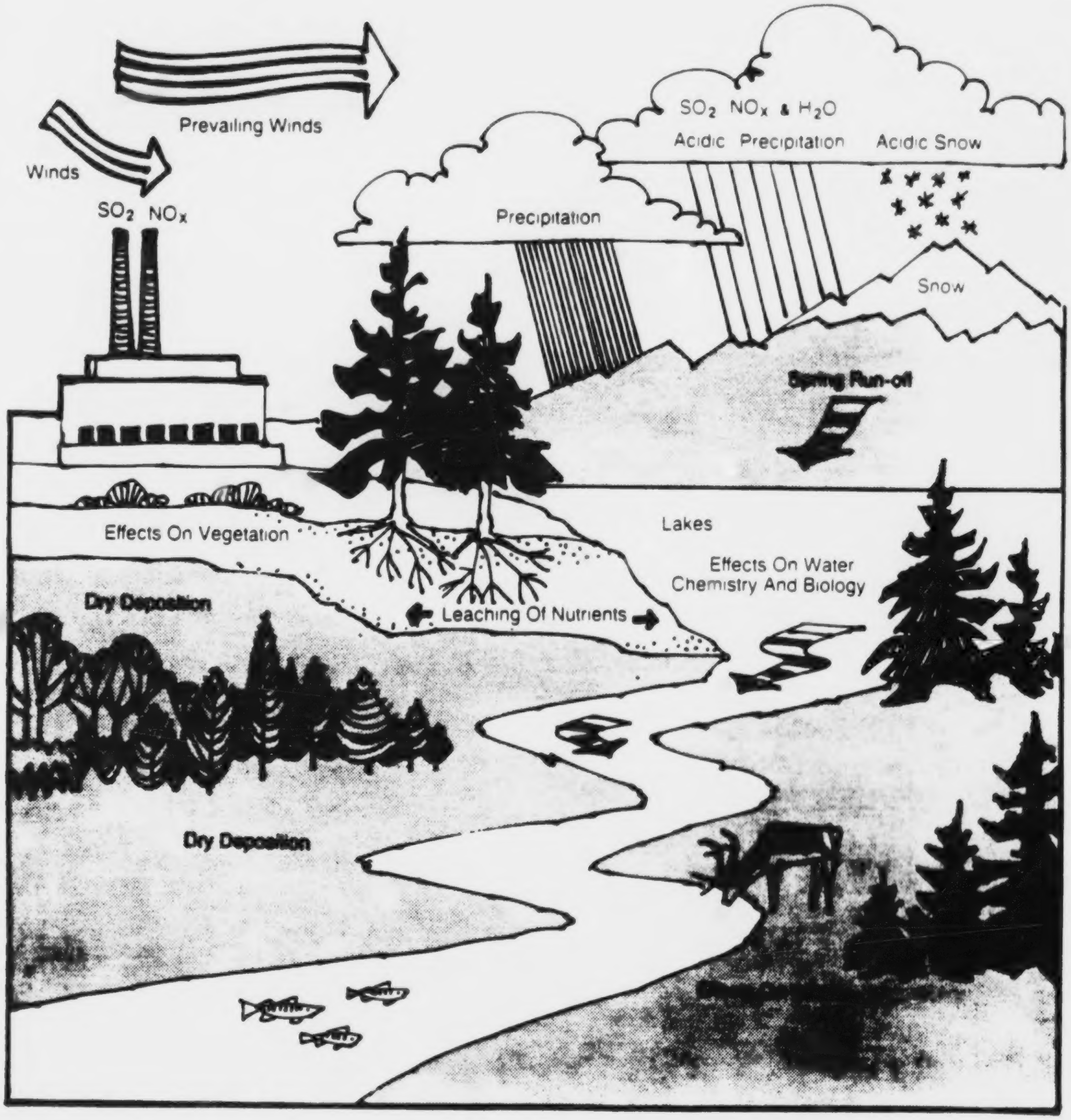
From *Focus on Pollution* by Alberta Environment. Reprinted by permission.

PESTICIDES


Aerial Spraying
Herbicide Spraying

From *Focus on Pesticides* by Alberta Environment. Reprinted by permission.

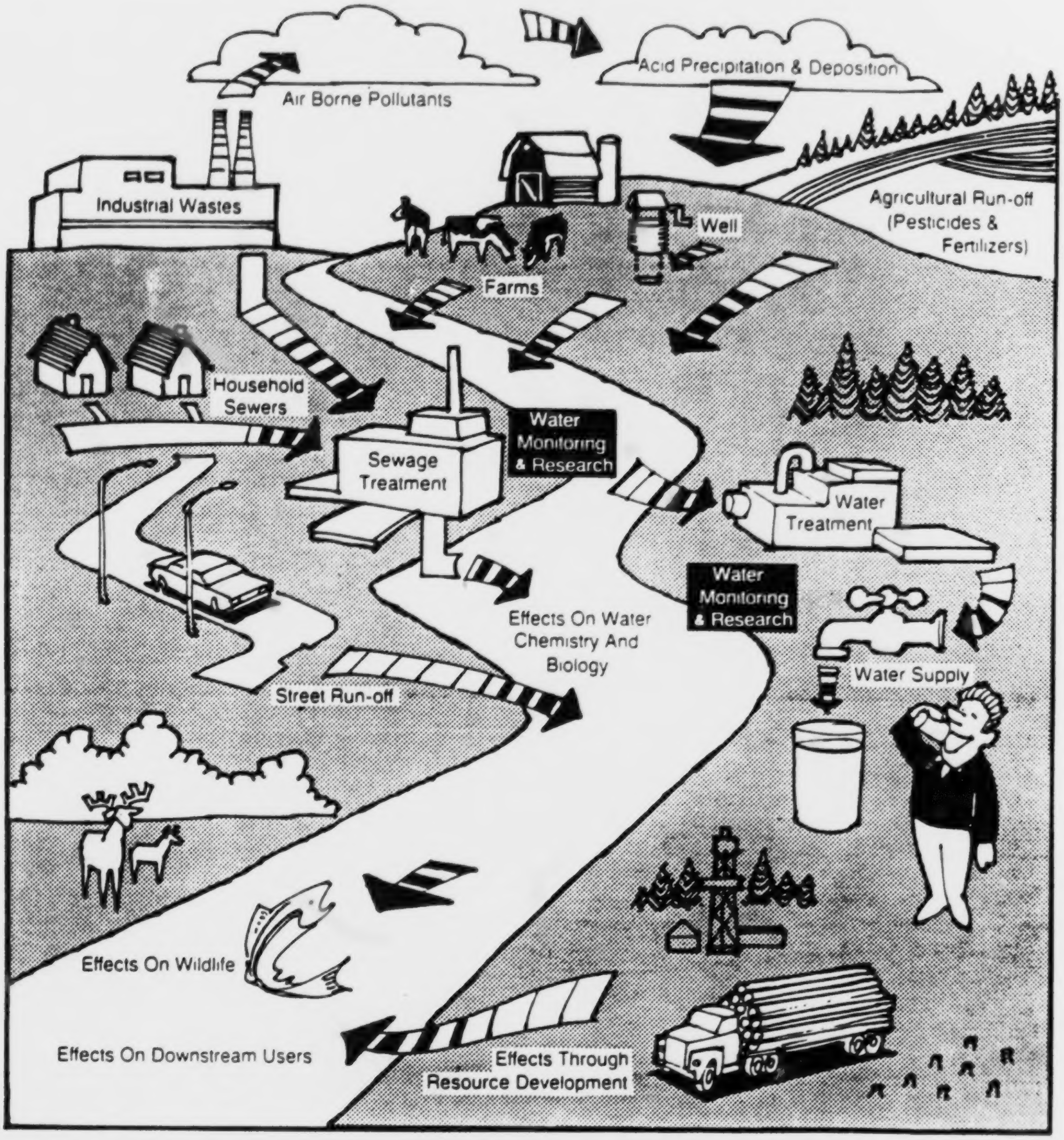
ACID DEPOSITION


Prevailing Winds
Winds
SO_2 NO_x
SO_2 NO_x & H_2O
Acidic Precipitation
Acidic Snow
Precipitation
Snow
Spring Run-off
Lakes
Effects On Vegetation
Effects On Water Chemistry And Biology
Leaching Of Nutrients
Dry Deposition
Dry Deposition

From *Focus on Acid Deposition* by Alberta Environment. Reprinted by permission.

RESOURCE 3: ENVIRONMENTAL ISSUES (cont'd)

WATER QUALITY


Air Borne Pollutants
Acid Precipitation & Deposition
Industrial Wastes
Well
Agricultural Run-off (Pesticides & Fertilizers)
Farms
Household Sewers
Water Monitoring & Research
Sewage Treatment
Water Treatment
Water Monitoring & Research
Effects On Water Chemistry And Biology
Water Supply
Street Run-off
Effects On Wildlife
Effects On Downstream Users
Effects Through Resource Development

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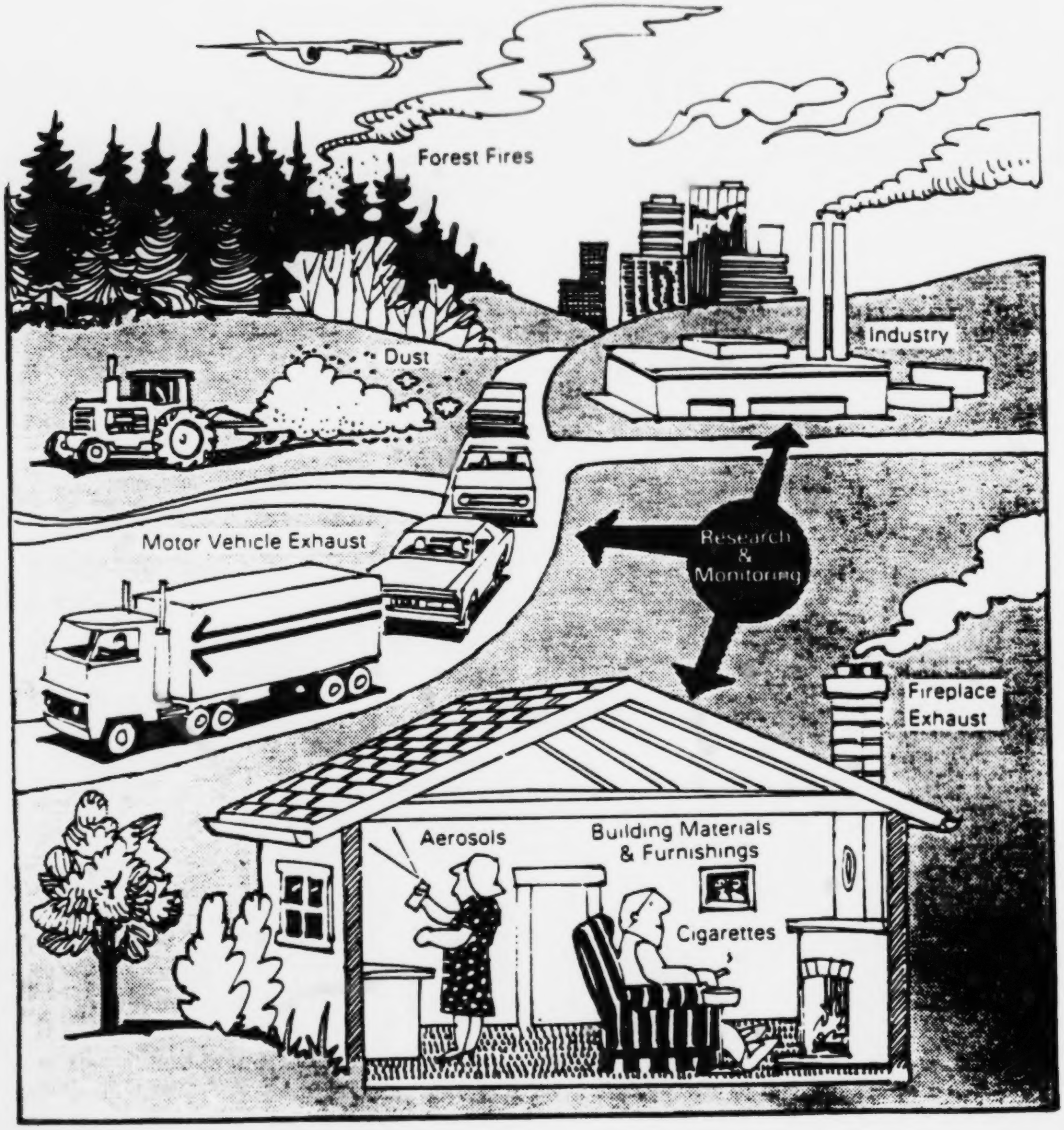
AIR QUALITY


Forest Fires
Industry
Dust
Motor Vehicle Exhaust
Research & Monitoring
Fireplace Exhaust
Aerosols
Building Materials & Furnishings
Cigarettes

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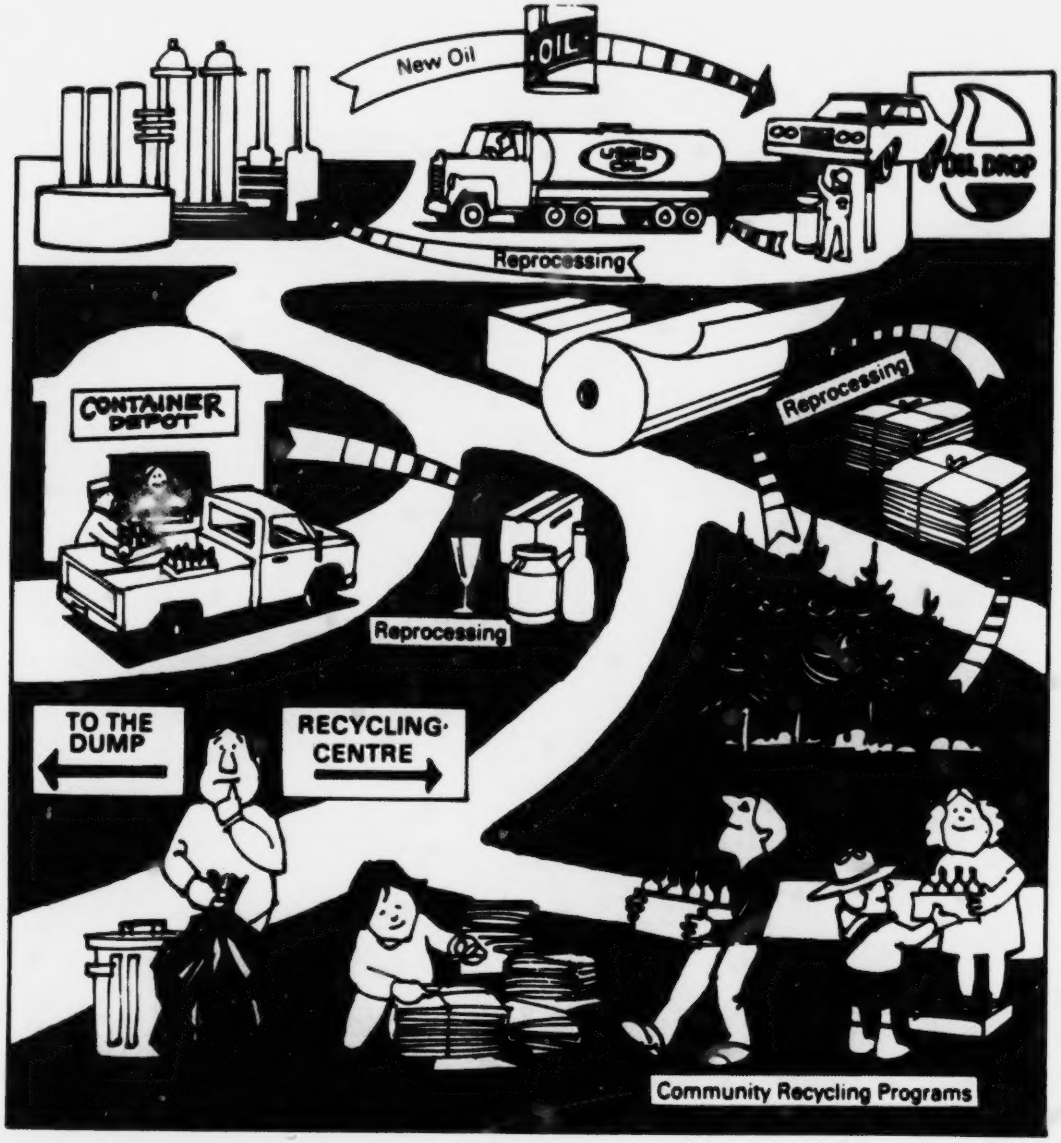
RECYCLING


New Oil
OIL
USED OIL
OIL DROP
Reprocessing
CONTAINER DEPOT
Reprocessing
Reprocessing
TO THE DUMP
RECYCLING CENTRE
Community Recycling Programs

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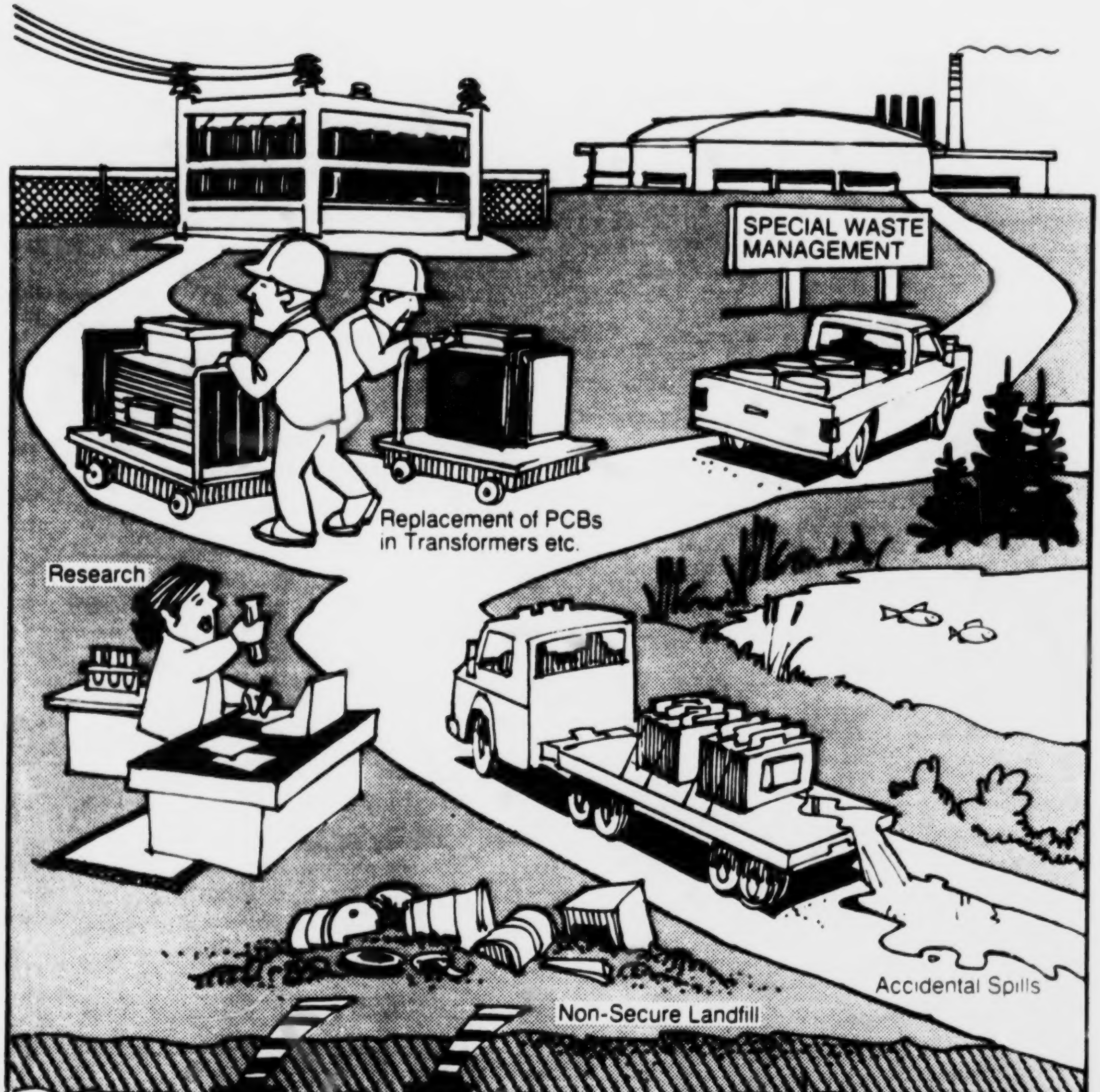
POLYCHLORINATED BIPHENYLS (PCB'S)


SPECIAL WASTE MANAGEMENT
Replacement of PCBs in Transformers etc.
Research
Accidental Spills
Non-Secure Landfill
Groundwater

From *Focus on PCB's* by Alberta Environment. Reprinted by permission.

RESOURCE 4: WHAT IS IN AN AEROSOL SPRAY?

PURPOSE

To illustrate how a technological product can be modified to overcome its disadvantages.

INTRODUCTION

The ozone of Earth's upper atmosphere shields life on Earth from the intense radiation of the Sun. This protective layer may, in fact, be one reason for Earth's ability to support life.

In the 1970's, there was a growing suspicion that pollution from high-flying aircraft, above-ground nuclear explosions, and aerosol spray cans was depleting our protective blanket of ozone.

What causes aerosol cans to threaten our ozone layer? Fluorocarbons – the ingredient that makes those cans go "ffft".

PROCEDURE

A. Go to a local supermarket or drugstore and make a list of products sold in aerosol containers.

B. Read several labels carefully and note the products that bear statements disclaiming fluorocarbons as propellants.

C. What is the propellant in each product that disclaims fluorocarbons as the propellant?

D. Look at each different kind of aerosol product. Is there alternative packaging for each type, such as a pump spray or squeeze bottle?

E. Answer the following questions.

   (1) What are the advantages of aerosol dispensers? Think of foam shaving cream as an example.
   (2) Fluorocarbons are still used in refrigeration units and heat pumps. Why is this use not a danger to the ozone layer?
   (3) What other technological products can you think of that have been modified because of disadvantages in their use?

RESULTS

Use of fluorocarbons as propellents in aerosol cans has been discontinued. Other propellents, such as hydrogen, are now used.

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NATURE OF SCIENCE

Learning to understand natural objects and events and to apply knowledge gained to a variety of practical situations is emphasized throughout the science program. Today's society requires that students are active investigators, possessing the critical and creative thinking skills that will enable them to interpret and evaluate information gathered through the senses. A focus on the nature of science and the inquiry process will enable students to understand the way in which scientific knowledge is gathered, as well as use this knowledge in conducting investigations of their own.

Learning activities used throughout the science program will enable students to demonstrate an understanding that:

- science is a disciplined way to develop explanations for the events and objects of the natural world
- science is comprised not only of an accumulated body of knowledge, but also of the processes by which that knowledge is developed
- empirical evidence plays an important role in the development of scientific knowledge
- physical laws and theories attempt to explain the universe
- scientific knowledge is not fixed but, rather, is based on theory, which may change as additional evidence accumulates
- scientific explanations are developed through interpretations and conceptual inventions that are theoretical in nature.

Additionally, the science program should encourage students to display:

- curiosity about events and objects in the natural world
- an appreciation of the beauty and complexity of the natural world
- a concern for accuracy and supporting evidence
- honesty and completeness in reporting and evaluating evidence
- open-mindedness in considering alternative ideas and interpretations
- critical-mindedness in evaluating inferences and conclusions
- confidence in personal ability to design and conduct a scientific investigation.

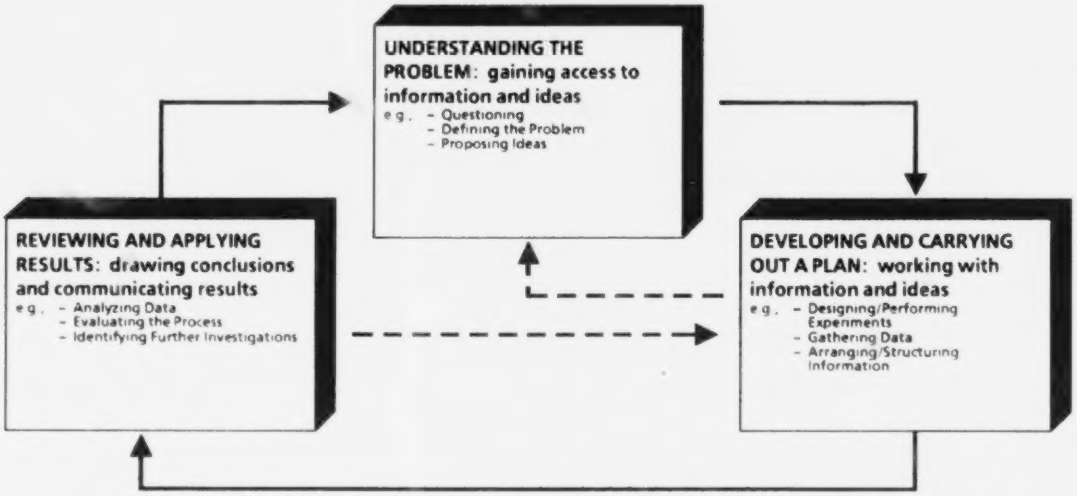
A variety of teaching and learning strategies that nurture an understanding of the nature of science have been included in this section of the manual. The strategies support active involvement in the inquiry and problem-solving processes, and include:

- A Model for Conducting Investigations in Science.
- Useful Strategies and Skills
  - Understanding the Problem
  - Developing and Carrying Out a Plan
  - Reviewing and Applying Results.
- Suggestions for Planning Investigative Activities.
- A Sample Lesson Plan.

A MODEL FOR CONDUCTING INVESTIGATIONS IN SCIENCE

Critical to conducting investigations in science is the attitude with which students approach the task. People are often uneasy and hesitant to involve themselves in situations where procedures are not easily determined and outcomes are not evident. Appropriate attitudes must be nurtured through an atmosphere that provides encouragement, flexibility and acceptance. Discussion and activity should foster student curiosity about natural events and an interest in trying to understand them. Students must be persuaded to take risks in planning investigative procedures and to develop a concern for accuracy, honesty and evidence in the investigations they perform. Students will be supported in their understanding of the inquiry process when investigations that relate to personal experience, interest and need are selected.

A model for conducting investigations in science is suggested below. This model provides a starting point and some ways of organizing efforts.


UNDERSTANDING THE PROBLEM: gaining access to information and ideas
e.g., – Questioning
– Defining the Problem
– Proposing Ideas
DEVELOPING AND CARRYING OUT A PLAN: working with information and ideas
e.g., – Designing/Performing Experiments
– Gathering Data
– Arranging/Structuring Information
REVIEWING AND APPLYING RESULTS: drawing conclusions and communicating results
e.g., – Analyzing Data
– Evaluating the Process
– Identifying Further Investigations

Specific actions suggested at each stage within the model represent possible strategies that might be used in conducting an investigation. Students may not always use each stage of the process and will select only those actions that are appropriate to purpose and ability. Students should, however, recognize the investigative process as a series of interrelated actions that lead to an outcome.

By bringing thought processes to the metacognitive level (e.g., helping students to become aware of the thinking skills and thought processes that they and others use), students will be better able consciously to select and use those strategies and skills that are appropriate to the situations they encounter. Research strongly supports the teaching practice of:

- modelling (talking through) the processes and skills that are appropriate to an investigation
- discussing the processes and skills that the student is presently in the habit of using (e.g., raising the level of metacognitive awareness)
- encouraging students to develop additional strategies that will structure and support the thought process.

This model for conducting investigations in science can be explicitly presented to students as an overall process and then used as a teaching and learning model.

USEFUL STRATEGIES AND SKILLS

Students need to develop and apply a range of strategies and thinking skills in order to investigate natural phenomena, solve practical problems and resolve science related issues. Some skills involve the use of formal operations (i.e., hypothetical thinking), and must be developed through carefully planned learning experiences that focus on their use. The process of mediation (e.g., asking appropriate questions, modelling and "talking through" complete thought processes) will assist students to develop and consciously use strategies and skills that are appropriate to the situations they encounter. Learner ability will determine the degree to which skills are applied at an independent level throughout investigations undertaken in the science program.

The list of skills suggested below serves to guide the design of learning experiences and the construction of assessment schemes. These skills are not intended to be developed separately or sequentially but, rather, concurrently with concept and attitude components within the science program.

Students will be expected to demonstrate an ability to:

- distinguish between relevant and irrelevant information
  e.g.,
  - define problems/identify issues
  - set goals by establishing purpose and direction
  - formulate questions to guide research/inquiry
  - identify variables
- gather information or data
  e.g.,
  - use an experimental design or research plan
  - make qualitative and quantitative observations
  - effectively use apparatus and equipment
- arrange or structure information so it can be readily understood or presented
  e.g.,
  - classify
  - order and identify patterns/trends
  - draw charts/graphs/diagrams
  - express data in the form of a mathematical relationship
- analyze data or information
  e.g.,
  - identify main ideas/attributes/components
  - identify patterns and relationships
  - identify errors
  - detect bias
- make connections among new ideas and prior knowledge, and generate information beyond that which is given
  e.g.,
  - explain and elaborate
  - predict and hypothesize
  - infer and generalize from the data or information
  - design experiments or devise a plan for research
  - identify further problems, questions and issues to be investigated
- integrate new information with prior knowledge
  e.g.,
  - summarize and communicate findings
  - develop consensus within a group
  - make a decision or develop a conclusion/solution
- assess the logic and quality of ideas/information
  e.g.,
  - consider consequences
  - establish criteria to judge data
  - assess a design or approach taken to inquiry, problem solving or decision making
  - assess the achievement of goals set.

UNDERSTANDING THE PROBLEM

QUESTIONING/DEFINING THE PROBLEM

> Questioning recognizes the need of the student to take an active role in initiating an investigation. Questioning may originate when the student recognizes a discrepant or unexplained event in the environment. Skill in questioning is built on the student developing ability to reflect on the discrepant event, to analyze the event in light of previous experience, and to formulate questions in a way that probes for specific meaning or knowledge. Initially the student may ask questions in terms that are difficult to answer, but with guidance and practice learns to evaluate, rephrase and redirect questions so that answers can be found, often on one's own. Questioning skill leads to skill in problem definition, a step which the student takes in assuming increased responsibility for finding answers.[1]

Questioning techniques modelled by the teacher are effective in developing an awareness of, and ability to ask relevant questions. In preparing students for an activity, teachers can:

- begin with divergent questions, so as to allow for a large number of answers and to provide for critical/creative thinking
- use convergent questions if students seem to be having difficulty
- ask questions that require students to engage in thinking at all levels (e.g., recall, application, analysis, synthesis, evaluation)
- encourage participation and thought by allowing an appropriate "response time" for each question that is asked.

CLARIFICATION/EXAMPLE

Questions That Involve Students in Investigation

- What are we looking for?
- What do we want to explain/investigate?
- What do you notice about this ...?
- What do you think might happen if ...?
- Why did ...?
- What should we do first?
- What is stopping us?
- If this is so, then ...?

Questions That Stimulate Creative Response

- What is my next step?
- How will I do that?
- How can I design a better ...?
- What is the relationship between ... and ...?
- Why did ... happen after ...?
- How would you design an experiment to ...?
- What might happen if you use ... instead of ...?
- What is the likelihood that ...?

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1. Adapted from *Science Process Skills and the Alberta Science Curriculum (A Position Paper)*, written by Bernie Galbraith and sponsored by Alberta Education, p. 18, 1983.

CLARIFICATION/EXAMPLE

Questions That Stimulate Analysis and Evaluation

- How did you know that ...?
- What does the data indicate?
- What caused ... to happen?
- How does ... apply to ...?
- How could you explain ... in another way?
- How might you use these results?
- How could we make our work easier another time?
- How could we improve it or make it better?
- What should we tell others?

Students should be given frequent opportunity to generate questions that are based upon the observations they make and the information they gather. The strategy that follows may be useful in developing student ability to formulate questions related to information they have read. Teachers may wish to modify this strategy according to nature of the investigation and the information being examined.

CLARIFICATION/EXAMPLE

A Strategy for Generating Questions[1]

1. Provide students with a copy of some reading material.

2. Ask students to read the first paragraph silently. Monitor students to ensure that they have read the paragraph by asking questions related to the outcome of the paragraph.

3. Ask students to go back to the beginning of the paragraph and silently read the first sentence again.

4. Encourage students to generate as many questions as possible that are based upon the first sentence. The teacher should respond to each question that is asked.

5. Reverse the roles of student and teacher. The teacher now asks questions of the students that are based upon the first sentence. Questions asked by the teacher should be of different categories than those asked by students (e.g., knowledge, comprehension, application, analysis, synthesis, evaluation). Students should answer each question asked by the teacher, or give a reason for not being able to answer. The teacher should provide responses for questions the student cannot answer.

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[1] Adapted from *SPELT: A Strategies Programme for Effective Learning/Thinking: Inservice Edition*, SPELT International Ltd., p. 114. Copyright 1987 by R. Mulcahy, K. Marfo, D. Peat and J. Andrews. Reprinted by permission.

PROPOSING IDEAS

> Strategies that establish a sense of direction to inquiry are identified in this skill area. Establishing a sense of direction is critically important to the inquiry process for, in science, answers to questions do not normally emerge spontaneously. Generally they emerge as the result of ideas that have been proposed and then tried to see if they work. The proposing of ideas is not always an external process, nor is it always done in a rational way. Ideas emerge out of a combination of reflection on what the learner already knows or supposes to be true. Whether by conscious rational thought, or by intuition, the student then takes the fundamental step of mentally associating two or more objects, events, properties and/or living things in the context of some type of relationship. The process of making this type of association may be a nearly instantaneous one, taking place in the fraction of a second after a question has been asked. For more difficult questions the process may be considerably extended, taking as long as several days or months, depending on the difficulty of the problem and the tenacity of the learner. Once "proposed", an idea may lead to formal investigation, or on further reflection may be rejected as unlikely or inappropriate. A number of ideas may be "proposed" within the student's mind, but only the most favoured one used to direct further thought and investigation.
>
> The relationship between the two component skills of "hypothesizing" and "predicting" is a complex one. If we all thought on the basis of formal logic, it would seem necessary for us to hypothesize before we could predict, for it is only logical that we should recognize a relationship before we can apply that relationship to a prediction. In actual patterns of thought (and particularly for the student who has not advanced beyond a "concrete operational" stage), conscious thought may appear to transcend the step of hypothesizing and go directly to predicting. This does not mean that the student cannot and does not hypothesize. It may only mean that the student is incapable of reflecting on mental processes and is thus incapable of describing those processes to us. The ability to reflect consciously on an hypothesis and the related ability to state an hypothesis may not develop until relatively late in the student's school career. It is thus appropriate that a student's ability to hypothesize during the early years be gauged indirectly through ability to predict.[1]

Encourage students to identify problems and propose ideas that are based upon their personal observations of familiar objects/events. Arouse curiosity and guide students' thoughts through discussion and the use of appropriate questioning techniques (see "Questioning/Defining the Problem", page 4).

The statements that follow provide additional suggestions for developing student ability to generate ideas about possible relationships and devise simple statements that can be tested by observation or experiment:

- Assist students to formulate questions/problems that arise from personal observations they have made. (e.g., Why did this group of plants grow so much taller than the others?)

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[1] Adapted from *Science Process Skills and the Alberta Science Curriculum (A Position Paper)*, written by Bernie Galbraith and sponsored by Alberta Education, pp. 18-19, 1983.

- Through discussion, generate ideas about possible relationships between objects/events that have been observed. (e.g., These plants may have grown taller because ... .)
- Encourage students to describe the relationships they propose with simple statements. (e.g., If I do ....., then .... will happen.)
- Distinguish between guessing and predicting. Use patterns/trends/repeated observations to predict the next occurrence of an event. (e.g., According to previous observations, which of these plants would you expect to grow taller? What is the basis of your prediction?)
- Provide opportunity for students to confirm/reject predictions they make through observation, measurement or experiment.
- Coach students in devising tentative explanations by asking appropriate chains of questions. (e.g., What factors seem to affect the growth of plants? Can plant growth be maximized by ... ?)
- Do not expect students to formulate sophisticated hypotheses. Encourage students to select suitable hypotheses from sets of alternatives they are given, and in some instances to formulate simple hypotheses of their own. The abstract process of "hypothesizing" will be difficult for students who are functioning at a concrete level.

DEVELOPING AND CARRYING OUT A PLAN

DESIGNING/PERFORMING EXPERIMENTS

> This skill area identifies those thoughts and actions by which the student tries out an idea that has been proposed. At an early level of skill, the student may not consciously reflect on the techniques used to "find out". Rather, the student may proceed directly to a procedure that fits the concept of what is needed to demonstrate the relationship already believed to exist. The tendency to jump to conclusions appears to be natural at early ages, with experience used only to support foregone conclusions rather than to evaluate them critically. It is only as the student advances in ability to think critically that reflective attention is given to the procedures used in experimenting. When the student reaches this stage, the concept of a fair test can be introduced. This concept can then be expanded by introduction of the related concepts of manipulated variable, responding variable and control variables.[1]

The process of designing an experiment is complex and requires the student to "plan" an investigation in order to obtain a solution to a problem or test an hypothesis. Planning an investigation requires the student to:

- identify the kinds of observations/measurements that are required to answer the question or problem. (e.g., If we were to investigate the idea that the amount of soil affects the growth of a plant, what should we do? What things would we want to measure? How should we measure them?)

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[1] Adapted from *Science Process Skills and the Alberta Science Curriculum (A Position Paper)*, written by Bernie Galbraith and sponsored by Alberta Education, p. 19, 1983.

- identify and control variables so as to make the experiment a "fair test" of the given question or problem. (e.g., Does it make any difference to the experiment if some plants are watered more frequently than others? What things should we do to make our experiment a fair test?)
- develop methods for collecting data and selecting apparatus and supplies that will be required
- devise sequential procedures to be followed and techniques for manipulating the apparatus and supplies
- decide upon the manner in which data will be recorded
- consider safety procedures that must be followed.

The process of designing an experiment can be modelled through teacher demonstrations that involve relationships familiar to the student. Following these demonstrations, plan other investigations through discussions that involve the whole class. As students develop an understanding of the process of designing an experiment, provide opportunities for students to plan and conduct simple experiments of their own.

CLARIFICATION/EXAMPLE

A Sample Outline for Designing an Experiment

1. Ask a question.
2. Write an hypothesis that answers the question.
3. Plan procedures that will be used to verify the hypothesis:
   - identify one variable to be tested
   - identify other variables that might be tested at another time
   - identify all controls that are necessary.
4. Select the apparatus and supplies that will be used.
5. Using words/diagrams, describe sequential procedures for performing the experiment.
6. Identify appropriate procedures for recording/communicating data that is gathered.

Students may be given procedures for many of the experiments they are to perform. Prior to conducting these experiments, provide opportunities for students to:

- understand the "thinking" behind the investigation
- consider alternative designs/procedures that might also be effective in answering the question or solving the problem.

Additional suggestions for designing an investigation are provided at the end of this section in:

- Resource 1: Writing a Lab Report
- Resource 2: A Sample Lab Report
- Resource 3: An Evaluation Guide for Lab Reports.

GATHERING DATA

> Observing is in some ways the most fundamental skill to science and it is usually the first skill that the student develops to a relatively high level of proficiency. In some ways younger students may be better observers than we adults, as they generally are more ready to accept a wide range of sensory input as worthy of their attention. Nevertheless, the skill is very much subject to development and improvement. One of the principal means by which the student improves skill is by developing the ability to focus thought and attention. Rather than relying on random observations of events, the student begins to recognize patterns of events and conceptualizes observations in terms of these patterns. The student also learns to quantify observations, or in effect, to measure. Measurement skills develop mainly with practice.
>
> The recording of observations and measurements has been included here as a major aspect of this skill. Initially the recording may be the listing of observations in a relatively unstructured way. With practice, the student learns to describe observations in the form of a sequenced narrative of actions and events. At a further level of sophistication the observations may be abstracted from the procedures and described in analytical or point form. At the most advanced level, the student is able to select an appropriate procedure for recording observations where the format is chosen on the basis of clarity rather than conformity to a rigid pattern.
>
> Skills in drawing pictures and diagrams are also part of the data gathering phase. Younger students are generally very ready to use pictorial representations to convey meanings that they have gleaned from their experiences. Initially the drawings may be more impressionistic than precise, with obvious shortcomings in the way relationships between elements have been treated and with obvious inaccuracies in proportion. The drawings nevertheless serve as a basis for the student to express and summarize experiences. As the student advances in skill (which will happen naturally given opportunities to practice), ability to show relationships and proportions gradually improves. At some point the formal skills of diagraming can be introduced, with considerable spin-off benefits to the student's interest and ability to examine objects critically.[1]

Provide opportunities for students to practise making both qualitative and quantitative observations through direct use of the senses, as well as through the use of specialized observation tools (e.g., microscopes, thermometers, balance scales). Attribute guides are useful in establishing a structure for observations, and also provide an outline that students can follow in describing their observations. In preparing an attribute guide, select attributes that are appropriate to the nature of the observations being made.

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1. Adapted from *Science Process Skills and the Alberta Science Curriculum (A Position Paper)*, written by Bernie Galbraith and sponsored by Alberta Education, pp. 19-20, 1983.

CLARIFICATION/EXAMPLE

An Attribute Guide for Describing an Object[1]

Object to be described: ______________________________

Colour:

Shape:

Size (e.g., height, width, thickness):

Weight:

Texture:

Temperature:

State of Motion (e.g., speed, evenness, relationship to other things):

Aroma:

Taste:

Measurement is the process of determining the dimensions/quantity of an object or event using standard units, numbers and spatial relationships. Science activities should provide opportunities for students to:

- make accurate measurements using metric units of length, capacity, mass, temperature and time
- develop estimation skills by making comparisons to a known standard
- combine familiar units of measure into other measurable dimensions (e.g., density, pressure, velocity)
- interpret the calibrations on measuring instruments used in the laboratory (e.g., beakers, thermometers, spring scales)
- select units and tools of measurement that are appropriate to the task performed
- recognize the approximate nature of measurement and evaluate the precision/accuracy of the measurements that are made
- design/construct simple measuring instruments that are useful in particular applications.

Teachers are encouraged to familiarize themselves with the measurement strategies suggested in the mathematics program, and use these strategies when developing related skills in the science program.

Additional suggestions for gathering and describing scientific data are provided in:

- Resource 4: Observing and Describing
- Resource 5: An Evaluation Guide for Observations.

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[1] Adapted from *SPELT: A Strategies Programme for Effective Learning/Thinking: Inservice Edition*, SPELT International Ltd., p. 102. Copyright 1987 by R. Mulcahy, K. Marfo, D. Peat and J. Andrews. Reprinted by permission.

ARRANGING/STRUCTURING INFORMATION

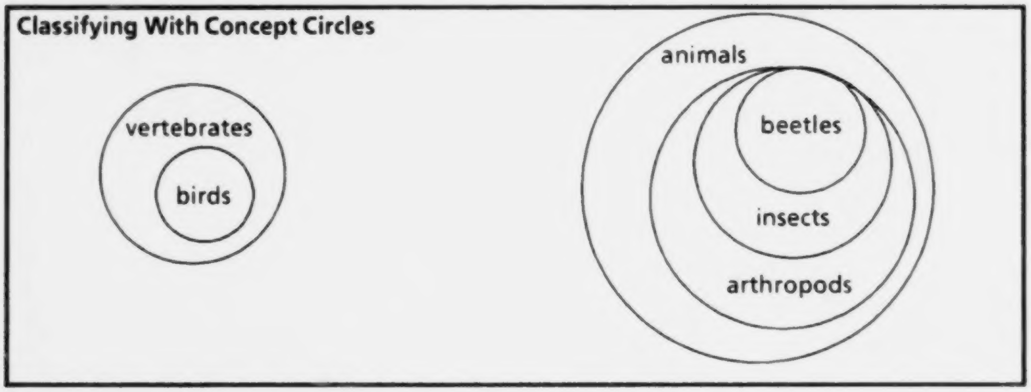
> Arranging and structuring information includes all those manipulations that are performed with data in order to make interpretations. Classifying is included as it is seen as a skill that leads to data interpretation. Classifying skill is also closely related to observation in that classification may be based on the observation of similarities and differences. As the student advances in classification skill, many classification decisions that were previously a matter of conscious deliberation come to be made automatically as a part of observation. Thus the distinction between classification, observation and interpretation may at times be blurred. Nevertheless, there appears to be a progression of classification skill from the use of simple category systems to the use of multiple category systems. There is also a progression in the conceptual level of the characteristics used as elements in the classification system.
>
> Other skills in this area are those which allow the student to obtain meaning from collections of data, where the meaning may not be evident in isolated observations or measurements. Skills to be developed are largely mathematical, but the development of skills of presentation and layout of data are also significant.[1]

One of the first steps in arranging information involves organizing "rough" data into more compact and meaningful forms. Provide opportunities for students to organize the data they collect by:

- ordering objects/events according to observable properties
- making qualitative and quantitative comparisons of objects/events
- classifying objects/events on the basis of observable similarities and differences
- performing simple calculations.

When classifying, assist students to recognize similarities, differences and interrelationships among the objects/concepts/events being examined by using simple diagrammatic representations (e.g., concept circles, concept maps).

CLARIFICATION/EXAMPLE


Classifying With Concept Circles

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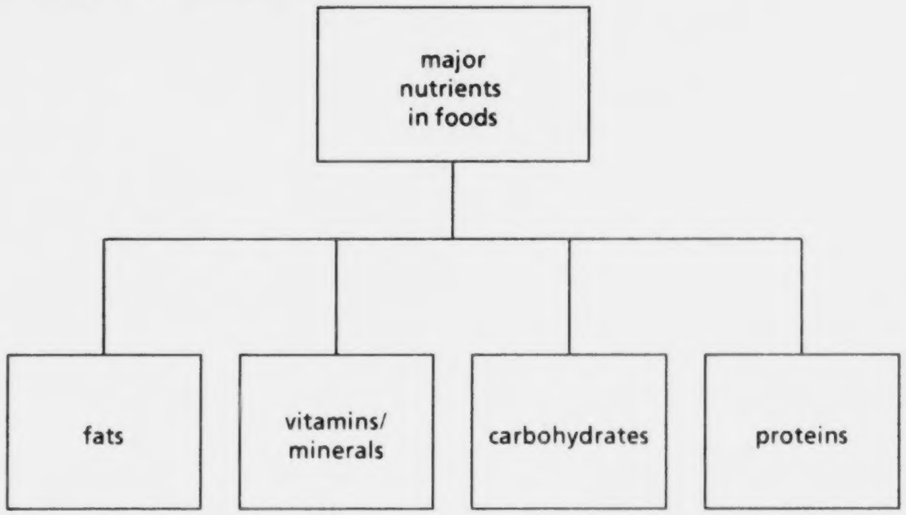
[1] Adapted from *Science Process Skills and the Alberta Science Curriculum (A Position Paper)*, written by Bernie Galbraith and sponsored by Alberta Education, p. 20, 1983.

CLARIFICATION/EXAMPLE

Classifying With a Concept Map



When presenting data, encourage students to illustrate the information they have collected in an organized and systematic manner, thus enabling anyone to understand its significance. Presentation methods should be chosen that are appropriate to the nature of the investigation and information collected. Students should gain experience in presenting data through the use of:

- oral reports/written reports that follow established guidelines
- sketches/pictures/diagrams
- simple tables/charts/graphs.

As students display their data, it may become apparent that there are recognizable patterns or trends in the data collected. Encourage students to identify these patterns or trends, and to make inferences and predictions that are based upon the patterns they observe.

REVIEWING AND APPLYING RESULTS

ANALYZING DATA

> The student must give meaning to the observations that have been made by analyzing and interpreting data. A first stage of analyzing data is inferring, a step in which the student makes a judgment about the evidence obtained in relation to original ideas or proposals. Inferring means making a judgment about a proposed relationship between objects, events, properties and/or living things. At an early level, the student may tend to make a categorical judgment, often inaccurate, on the basis of very little evidence. As skill level advances, the student will likely require much more evidence before making an inference. The inferences made by the more skilled student will likely be expressed in language that is more tentative and more contextual than for a less skilled student. There will be fewer statements of the kind that begins "This proves ..." and more statements of the kind "The data indicates that ...".
>
> The conceptualization of inferred relationships is also included as part of this skill area. This "mental modelling" may take a variety of forms. It may involve the use of some familiar physical system as a model or metaphor for another; it may use some type of spatial model as "a picture" of what the data has shown; it might also be in the form of a mathematical model. As skill in formulating models develops, the student is increasingly able to generate models characterized by a high level of abstraction.[1]

Students should have an opportunity to examine data and formulate their own interpretations before "answers are given". Emphasis should be placed on formulating an explanation rather than the explanation. The process of analyzing data will require students to:

- generalize data by inferring relationships
- distinguish between inference and observation
- develop appropriate explanations/theories/models based on data that is gathered
- evaluate the hypothesis in terms of the existing data.

Assist students to identify cause and effect relationships in familiar natural events. Students should realize that there may be more than one cause for certain events. Encourage students to identify as many causes as possible for a given problem. Questions like "What might happen if ...?" and "How does ... apply to ...?" will encourage students to consider cause and effect relationships and apply these to related situations.

Physical and mental models often provide a useful method of describing unfamiliar phenomena in terms of something that is familiar. Physical models are particularly worthwhile in aiding comprehension of difficult concepts. Examples of models that students may find helpful include:

- a picture of an eroded area in the environment
- a diagram of a human body system
- a physical model of an electric circuit
- a mental model of an atom.

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[1] Adapted from *Science Process Skills and the Alberta Science Curriculum (A Position Paper)*, written by Bernie Galbraith and sponsored by Alberta Education, p. 21, 1983.

In order to evaluate a hypothesis, students must consider the "fit" of the data they collect with the original hypothesis. On the basis of evidence collected, students will decide to confirm or reject their hypothesis. It may be necessary to modify or restate the hypothesis and undertake further investigation. Encourage students to relate knowledge gained from their interpretation of data to related situations.

EVALUATING THE PROCESS

Subsequent to conducting an investigation, provide opportunities for students to examine critically the procedures/thought processes they have used and to compare their views with those of other students. Ask questions that will encourage students to:

- consider the adequacy of the data in supporting inferences that were made
- distinguish between reasonable inferences and unsupported guesses
- identify possible sources of error in the data collected
- identify intervening/uncontrolled variables that may have affected data collection and results
- recognize limits to interpretations that are based on sample size.

IDENTIFYING FURTHER INVESTIGATIONS

Further problems/questions are often identified as a result of experiments that are performed. Additional investigations may serve to:

- increase the level of confidence in the inferences/explanations that were made
- test the range of applicability of the explanation
- study the effect of different variables/conditions
- examine discrepant events
- solve new problems that have been identified as a result of experimentation.

As time permits, provide opportunities for students to undertake further investigations. These investigations may take the form of:

- demonstrations/experiments
- projects for a science fair
- field trips
- interviews/class visitors.

SUGGESTIONS FOR PLANNING INVESTIGATIVE ACTIVITIES

Themes developed in this manual provide opportunities for students to conduct investigations within a variety of meaningful contexts. Students should recognize that the strategies and skills they use in conducting investigations are "lifetime tools" and, when chosen according to purpose and need, are useful in a variety of practical situations.

The following suggestions may be useful in helping students to plan and conduct investigations within the science program.

- Share the model for conducting investigations with all students. The model provides structure to the overall process, as well as specific strategies/skills that can be used at each stage of the process. Familiarity with the model will increase the student's repertoire of strategies that can be used in performing an investigation.
- Encourage students to be creative and experimental in their approach to investigations. While useful in the structure it provides, the model should not be interpreted as consisting of fixed stages and strategies. Its use will depend on individual problems and individual students.
- Ensure that investigations do not become tedious or unrealistically complex. Data related to the phenomena investigated must be readily available, and should be relevant to student interest and experience.
- Foster the development of attitudes and behaviours that promote student thinking and ability to monitor progress through the inquiry process:
  - open-mindedness in considering alternative ideas and interpretations
  - concern for accuracy and evidence
  - honesty and completeness in reporting and evaluating evidence
  - critical mindedness in evaluating inferences and conclusions
  - sub-vocal rehearsal/self-talk (e.g., "Where was I?", "Am I done with this?", "What comes next?").
- Encourage students to recognize how the model for conducting investigations in science provides a general plan for action that is also effective in guiding investigations in English, mathematics, social studies and the occupational program, and how specific skills used at each stage within the model may vary according to the nature of the problem or investigation.

When planning laboratory investigations, provide variation in student activities so as to ensure greater interest and participation. Plan activities that:

- require formal laboratory write-ups, and others that are short involving no formal write-up
- involve individual work, and others that involve group work
- focus on the development of only one strategy or skill, and others that involve several strategies and skills
- acquaint students with a variety of phenomena through a "work stations" approach.

Although laboratory activities and experiments represent an important part of the investigative process, they should not become the sole teaching strategy. A successful lesson may often include the use of more than one teaching strategy.

e.g., – questioning
– laboratory activities
– individual and group projects
– class discussions
– teacher modelling/demonstrations
– case studies and debates
– community partnerships
– games and simulations
– technology and the media resources

The sequence of activities outlined below may assist teachers in planning investigative lessons that involve a variety of teaching and learning strategies.

- Pose a problem.
- Establish an experimental design aimed at solving the problem.
- Provide (or have students gather) data required to solve the problem.
- Have students study and interpret their data. Guide activities through the use of leading questions that focus student attention on relevant aspects of the data.
- Formulate generalizations on the basis of data collected. Use questioning techniques that will facilitate the student's use of personal reasoning skills.
- Have a class discussion on the meaning and limitations of the data, the relationship of the data to other problems, and possible applications to everyday life.
- Use questions that may have arisen to extend learning to new areas.

A SAMPLE LESSON PLAN

This sample lesson plan illustrates how the model suggested for conducting investigations in science may be applied to a practical situation. Although this investigation relates to heat and its effects on familiar materials, similar methodology could be used in developing other concepts in the science program. The sequence of activities would require the use of several class periods and may need to be modified according to student needs and local circumstances.

OBJECTIVES

- To investigate the effects of heat on familiar materials.
- To recognize everyday applications of the expansion and contraction of materials.

I. UNDERSTANDING THE PROBLEM: GAINING ACCESS TO INFORMATION AND IDEAS

- Facilitate a class discussion. Develop an anticipatory mental set for the problem at hand. Relate the problem to personal experience (e.g., "You have just purchased a jar of relish and are unable to open it. What are some procedures you might use to remove the lid?"). Ask questions and cite examples that relate to the effects of heat on solids, liquids and gases.

QUESTIONING

IDENTIFYING THE PROBLEM

- Discuss the Kinetic Molecular Theory and its use in explaining the behaviour of matter. Make an analogy that illustrates this theory (e.g., "If one hundred people were placed in a room, it might be crowded but they would fit. If they were asked to do some warm-up exercises, they would need more room. That is, they would expand the need for space.").

GATHERING INFORMATION

- Gain additional information by reading about heat and its effects on matter.

FORMULATING QUESTIONS

- Ask students to identify instances in their personal life where materials used are affected by heat and temperature. Encourage students to consider related situations/tools/materials encountered in their occupational program, at home and in the natural environment. Identify questions or problems experienced by students in these situations (e.g., removing a radiator cap, inflating a bicycle tire).

DEFINING PROBLEMS

II. DEVELOPING AND CARRYING OUT A PLAN: WORKING WITH INFORMATION AND IDEAS

- Ask students to formulate simple hypotheses about their personal experiences with heat and matter.

FORMULATING HYPOTHESES

- Provide opportunities for experimentation with heat and matter in situations involving solids, liquids and gases. Design experiments that will validate hypotheses. Students often find this difficult and may require assistance in designing their experiment. Discuss observations to be made in the experiment, measurements that might be taken in determining change in the materials and a method for recording data.

PLANNING AND EXPERIMENTING

GATHERING AND ARRANGING DATA

- Students who are unable to design their own experiments should be given opportunity to pursue investigations and procedures that are teacher-directed.

III. REVIEWING AND APPLYING RESULTS: DRAWING CONCLUSIONS AND COMMUNICATING RESULTS

• Discuss and evaluate hypotheses that have been made after considering the outcomes of student investigation. Were predictions correct? Provide opportunities for students to communicate their inferences verbally, in written form or through models and diagrams.	EVALUATING MAKING INFERENCES COMMUNICATING
• Discuss the beneficial and detrimental effects of expansion and contraction (e.g., produces soil out of rock but also causes deterioration of sidewalks).	IDENTIFYING CAUSE AND EFFECT
• Through brainstorming, identify a number of technologies that apply principles of expansion and contraction. Examine technologies used by students at home and in their occupational program (e.g., internal combustion engine, thermometers, food preservation).	APPLYING INFERENCES
• Discuss positive and negative effects of these technologies on our lives. Should any of these technologies be rejected by society because of harmful effects on man or environment?	DRAWING CONCLUSIONS/ MAKING DECISIONS
• Identify personal/societal needs that might be met by new technologies that apply principles of expansion and contraction. Challenge students to devise such technologies.	IDENTIFYING FURTHER PROBLEMS/ QUESTIONS TO INVESTIGATE
• Apply related concepts to other areas in the science program (e.g., electrical-thermal systems).	

RESOURCE 1: WRITING A LAB REPORT

You have probably written lab reports in the past. A report is often a brief summary of an event. In the case of a scientific report, the event is usually staged or created in a controlled environment and called an experiment.

All experiments start with a guess, or as the scientist calls it, a hypothesis. The hypothesis determines what investigation is carried out because it contains the question which must be answered by the experiment.

The following headings suggest one way to structure a lab report.

Title	A few words indicating the nature of the investigation.
Object	A sentence or two that describes what the experimenter wishes to find out.
Apparatus	A list of materials used. Apparatus can be reused after the investigation.
Supplies	A further list of materials used. Supplies, unlike apparatus, are consumed during the experiment.
Procedure	The steps taken to carry out the investigation. It is customary to number the steps in the sequence in which they should be carried out. Use the present tense.
Observations	The findings of your investigation. Observations may be qualitative or quantitative. Quantitative observations, also called data, involve numbers and are often collected in tables, charts or graphs. A sample quantitative observation would be, "The solution boils at 108° C". Qualitative observations do not involve numbers and may be written in either sequence or paragraph form, using the past tense. A sample qualitative observation might be, "A red-brown gas escaped".
Conclusions	The answer to the question raised in the **object** section. It is based on your observations and data collected during the investigation and is usually written in the present tense. It will either prove or disprove the hypothesis.

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RESOURCE 2: A SAMPLE LAB REPORT

THE EFFECT OF DISSOLVED SALT ON THE BOILING POINT OF WATER

Object To determine the effect of sodium chloride (NaCl) on the boiling point of water.

Apparatus 500 mL beaker, support stand, ring clamp, wire gauze, bunsen burner, flint striker, thermometer, triple beam balance, 500 mL graduated cylinder, watch with a second hand, stirring rod, beaker tongs or oven mitts.

Supplies Distilled water, filter paper, NaCl.

Procedure

Part A: Control

1. Measure 300 mL of distilled water in a graduated cylinder. Pour the water into the beaker.
2. Attach the ring clamp to the support stand at a height of about 20 cm. Place the wire gauze on the ring clamp.
   Safety Note: Be certain to clear the bench area of any paper, books, or other inflammable materials.
3. Set up a bunsen burner and light it before placing it beneath the ring clamp. Now adjust the height of the flame and the height of the ring clamp so that the tip of the blue inner flame is about 1 cm from the lower surface of the wire gauze. Finally, set the burner under the gauze.
4. Record the initial temperature of the water to the nearest degree.
5. Place the beaker on the wire gauze and record the temperature every two minutes until a constant temperature is obtained for at least three consecutive readings.
   Safety Note: Do not stir the solution with the thermometer because repeated tapping of the tip against the wall of the beaker may cause the thermometer to break. Use a stirring rod.
6. Using oven mitts or beaker tongs, remove the beaker from the stand and place it on a heat resistant pad. Empty the beaker and let it cool to room temperature before starting Part B.

Part B: Salt at 1 g/100 mL

1. Weigh 3 g of NaCl on a piece of filter paper.
2. Measure 300 mL of distilled water and pour it into the beaker.
3. Dissolve the 3 g salt in the water by stirring.
4. Record the initial water temperature.
5. If necessary, adjust the height of the heating apparatus as in step 3 of Part A.
6. Place the solution on the wire gauze. As before, record the temperature of the solution every two minutes until a constant temperature is obtained for at least three consecutive readings.
7. Remove the beaker from the stand using tongs or mitts. Empty the solution. Rinse and dry the beaker before starting Part C.

Part C: Salt at 2 g/100 mL

1. Weigh 6 g of NaCl on a piece of filter paper.
2. Repeat steps two to seven in Part B using 6 g instead of 3 g of salt.

Observations

1. Boiling appeared to be the same in all three experimental solutions.
2. The solutions appeared to heat at approximately the same rate.
3. The table below illustrates the temperatures recorded while heating the three solutions.

DATA TABLE

Time in Minutes	Temperature (° C)		
	300 mL water	300 mL water and 3 g NaCl	300 mL water and 6 g NaCl
0	20	21	20
2	25	27	26
4	38	40	40
6	50	49	52
8	70	69	71
10	93	88	90
12	100	102	103
14	101	102	103
16	100	102	103

Conclusions

1. Dissolving NaCl in water tends to increase the boiling point.
2. It appears that the higher the concentration of NaCl, the higher the boiling point. However, the experiment should be repeated with several solutions of higher concentration before this inference can be confirmed.

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RESOURCE 3: AN EVALUATION GUIDE FOR LAB REPORTS

To assess how well you wrote your laboratory report answer the questions listed below and give yourself a mark up to the maximum score for the item in question. Then add up your score and read the marking scale below.

	Possible Score	My Score
1. Does your report have the following components each with its own heading? Title Object Apparatus Supplies Procedure Observations Data table Conclusions	6	
2. Is the object consistent with the hypothesis?	5	
3. Is the procedure listed as a series of chronological events?	3	
4. Did you use the present tense in the procedure?	2	
5. Could another student repeat your experiment with your report as the only instructions?	3	
6. Are your qualitative observations easily understood?	3	
7. Are your qualitative observations in complete sentences?	4	
8. Are your quantitative observations displayed in a data table?	2	
9. Does the data table have a title?	2	
10. Does the data table have column headings?	3	
11. Are the units clearly indicated in the data table?	2	
12. Are your conclusions consistent with the data collected and observations made?	5	
Total	40	

RESOURCE 3: AN EVALUATION GUIDE FOR LAB REPORTS (cont'd)

Scale Point

One	The report is incomplete. The format does not follow the model. The lab report is rated at 0 to 14 points.
Two	There are some omissions and format problems. The report needs revision. It is rated at 15 to 24 points.
Three	The lab report is almost complete and attention has been made to format. The report is rated at 25 to 32 points.
Four	The lab report has a clear, careful presentation in the standard format. It is rated at 33 to 40 points.

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RESOURCE 4: OBSERVING AND DESCRIBING

Observations are recorded through descriptive writing. You must be accurate and precise without using unnecessary words. Moreover, the description must state only what is observed, never what is suspected, inferred or believed. Eliminating these interfering opinions is often difficult but in time you will become quite conscious of them.

There are two basic types of observations.

- **Qualitative** observations describe the general characteristics of an object. An example is "The automobile is a blue sedan."
- **Quantitative** observations involve measurement of an object. An example is "The automobile was 2.5 m long."

Scientists must be precise and attempt to gather as many quantitative observations as possible. This is why people often say that "mathematics is the language of science".

Observations, sometimes reported in paragraphs, are most often written as complete sentences in lists. If a series of quantitative observations are collected they are usually put in a chart so that the reader can get an overview of the data at a glance. The chart may also be converted to a line graph or a bar graph to illustrate the pattern indicated by the data.

ASSIGNMENT 1

Your teacher will give you and your partner an everyday object such as a candle or a paper cup. Your task is to write the best series of observations to describe the object. Keep your qualitative and quantitative observations separate. It should be possible for you to list at least 50 or 60 observations in 30 minutes.

ASSIGNMENT 2

Working as an individual, you will be assigned something for observation. As you did in the previous activity, record as many qualitative and quantitative observations as possible on separate lists.

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RESOURCE 5: AN EVALUATION GUIDE FOR OBSERVATIONS

Your assignments in Resource 4 can be marked using the list of criteria below. Try answering the questions and marking your assignments yourself; then revise your observations to obtain a better mark.

	Possible Score	**My Score**
1. Did you list qualitative observations and quantitative observations? Have you presented them separately?	4	
2. Is each observation presented in a full sentence? If you read each one separately, can you tell what it means without referring to the others?	4	
3. Are any of your statements not observations? Deduct one mark each time you find: • an **opinion** • an **inference** • a **belief**, or • a **suspicion**. Check separately for each of them.		
4. Did you collect any quantitative data that can be tabulated? Have you presented these in a data table? Be sure your table has:		
• a title	2	
• a heading for each column and	3	
• a unit expressed for each.	2	
Total:	15	

Scale Point

One The lists offer little accurate description. The description obtains 0 to 9 points.

Two Accurate description has been provided, but either the format of the presentation is weak or a great deal of irrelevant material – opinions, inferences, beliefs, suspicions – has been included. The description obtains 10 to 12 points.

Three Accurate description has been effectively presented. Data are appropriately tabulated. The description obtains 13 to 15 points.

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SCIENCE AND TECHNOLOGY

Science and technology combine to affect almost every aspect of our lives. Students need to understand what science and technology are, and how they interact in producing familiar products and processes. Students also need to become familiar with the technological problem-solving process, and gain experience in using this process to solve practical problems involving science and technology.

Learning activities used throughout the science program will enable students to demonstrate an understanding that:

- technology facilitates the solving of practical problems
- technological development includes both products and processes
- the functioning of products and processes may be explained using scientific knowledge
- science can be used to advance technology, and technology can be used to advance science
- existing and emerging technologies have application in many everyday and work-related situations
- scientific knowledge and technology have limitations.

Problem-solving activities should be selected on the basis of the opportunities they provide for students to:

- develop confidence in personal ability to solve practical problems
- use critical and creative thinking skills
- recognize and respect alternative strategies that may be used in solving problems
- use psychomotor skills
- appreciate efficiency and design in technological products/processes
- appreciate how science and technology work to help one another.

A variety of teaching and learning strategies that illustrate interactions between science and technology and their influence on our daily lives have been included in this section of the manual. The suggestions support active involvement in solving practical problems involving science and technology, and focus attention on:

- The Relationship Between Science and Technology
  - Distinguishing Between Science and Technology
  - Interactions Between Science and Technology.
- A Model for Solving Technological Problems.
- Suggestions for Planning Problem-Solving Activities.

THE RELATIONSHIP BETWEEN SCIENCE AND TECHNOLOGY

DISTINGUISHING BETWEEN SCIENCE AND TECHNOLOGY

Science is the process of answering questions that arise from curiosity about natural phenomena. Science orders our knowledge of the natural world and allows us to predict the outcome of natural events. Technology, on the other hand, is the process of using scientific knowledge and other resources to develop products and processes. When we engage in technology, we attempt to solve practical problems in order to meet the needs of an individual or society. An engineering approach rather than a scientific approach is used in technology.

CLARIFICATION/EXAMPLE

Examples of Science Include:

- finding out how something "works"
- investigating the cause of acid rain
- classifying plants on the basis of observable characteristics.

Examples of Technology Include:

- the development of vaccines to control disease
- the development of consumer products (e.g., home appliances, canned foods, automobiles)
- the development of a new computer game.

The science program should provide opportunities for students to distinguish between familiar situations involving science and those involving technology, and to recognize how technology influences various aspects of their everyday lives (e.g., food, shelter, clothing, transportation, health). The chart that follows compares the scientific and technological processes and may be useful in structuring related activities.

	SCIENCE	TECHNOLOGY
TYPE OF ACTIVITY:	Theoretical	Practical
PROBLEMS ARISE FROM:	Curiosity about events and phenomena in the natural world	Wants/needs of individuals and society to accomplish specific tasks
RELATED QUESTIONS:	● Why does ... ? ● How do we know that ... ?	● What can we do to ... ? ● Will it work?
STRATEGY:	Scientific Inquiry	Technological Problem Solving
OUTCOMES/ SOLUTIONS:	Knowledge about natural phenomena	Products and processes designed to achieve intended purposes
EXAMPLES:	Why does my coffee cool so quickly? (Heat energy is transferred by conduction, convection and radiation.)	How can I keep my coffee hot? (A thermos is designed and constructed to keep liquids hot longer.)

Sample activities that will help students to distinguish between science and technology are provided at the end of this section in:

- Resource 1: How Does Technology Affect Our Everyday Lives?
- Resource 2: How Frequently Do I Make Choices About Technology?
- Resource 3: How Are Science and Technology Different?
- Resource 4: What Do Engineers and Scientists Do?

INTERACTIONS BETWEEN SCIENCE AND TECHNOLOGY

Science and technology interact and advance one another. Scientific principles frequently contribute to the development of technological devices and processes. These technologies, in turn, may identify significant questions that lead to the discovery of other scientific principles. Sometimes a technological device or process is developed without knowledge of the scientific principle behind it. This technology may then lead to the discovery of new scientific principles.

SCIENCE ⟷ TECHNOLOGY

Teachers are encouraged to focus attention on the interaction of science and technology at appropriate times throughout the science program. By asking relevant scientific and technological questions, students can be encouraged to make logical connections between science and technology, and to recognize:

- the scientific principles upon which familiar technologies are based
- technological products/processes that are based upon scientific principles being studied.

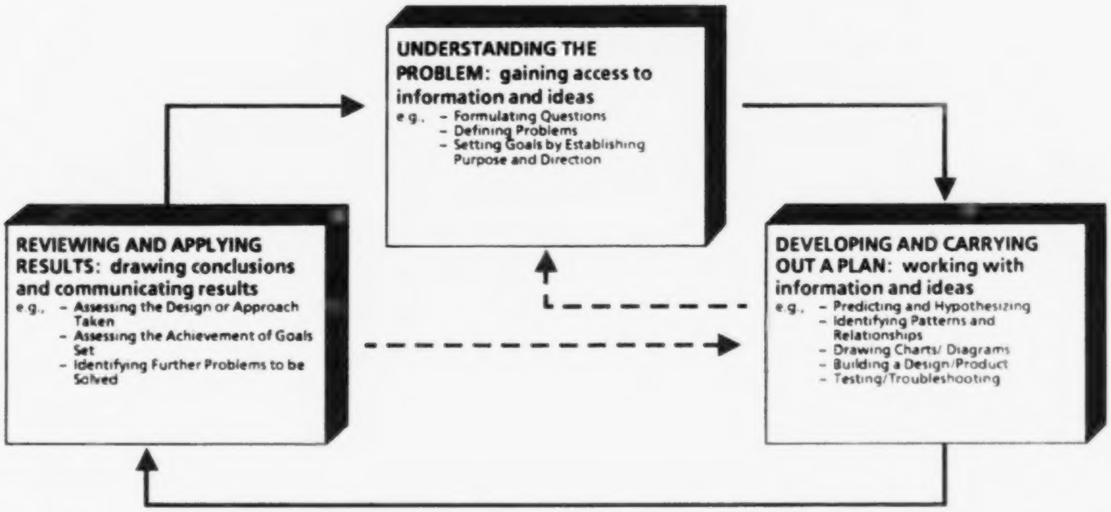
Activities that illustrate how science and technology interact are provided at the end of this section in:

- Resource 5: What is the Scientific Basis for Technology?
- Resource 6: What is a Technological System?

A MODEL FOR SOLVING TECHNOLOGICAL PROBLEMS

Critical to solving problems involving science and technology is the attitude with which students approach the task. Students may be hesitant to involve themselves in situations where procedures are not easily determined and solutions are not evident. Appropriate attitudes can be nurtured through an atmosphere that provides encouragement, flexibility and acceptance. Discussion and activity should foster student interest and desire to solve practical problems. Students need to be persuaded to take risks that are associated with inventing new solutions to practical problems. Students also need to understand the importance of planning and testing alternative ideas when designing a product or process that serves an intended purpose. Particular emphasis should be given to practical problems that incorporate hands-on activities in their solution.

A model for solving practical problems involving science and technology is suggested below. This model provides a starting point and some ways of organizing problem-solving efforts.


UNDERSTANDING THE PROBLEM: gaining access to information and ideas
e.g., – Formulating Questions
– Defining Problems
– Setting Goals by Establishing Purpose and Direction
REVIEWING AND APPLYING RESULTS: drawing conclusions and communicating results
e.g., – Assessing the Design or Approach Taken
– Assessing the Achievement of Goals Set
– Identifying Further Problems to be Solved
DEVELOPING AND CARRYING OUT A PLAN: working with information and ideas
e.g., – Predicting and Hypothesizing
– Identifying Patterns and Relationships
– Drawing Charts/ Diagrams
– Building a Design/Product
– Testing/Troubleshooting

Specific actions identified at each stage of the problem-solving process represent possible strategies that might be used in solving a problem. Students may not always use each stage of the process, and will select only those actions that are appropriate to purpose and ability. Students should, however, recognize problem solving as a series of interrelated actions that lead to a solution or outcome.

By helping students to become aware of the thinking skills and thought processes that they and others use, students will be better able consciously to select and use those strategies and skills that are appropriate to the situations they encounter. Teachers are encouraged to:

- model (talk through) the processes and skills that are appropriate to solving a particular type of problem
- discuss the processes and skills that students are presently in the habit of using
- coach students in developing additional strategies that will structure and support appropriate thought process.

This model for solving technological problems can be explicitly presented to students as an overall process and then used as a teaching and learning model in problem-solving situations.

The chart that follows suggests student activities that may be appropriate at each stage of problem solving represented in the model.

UNDERSTANDING THE PROBLEM	• identifying problems • identifying sub-problems • asking questions • identifying relationships
DEVELOPING AND CARRYING OUT A PLAN	• identifying alternative approaches/designs for solving the problem • developing/interpreting simple diagrams that illustrate problem-solving designs • developing/interpreting flow charts that represent approaches to problem solving • constructing prototypes • testing/troubleshooting • carrying out a problem-solving approach
REVIEWING AND APPLYING RESULTS	• evaluating a design • evaluating a problem-solving approach • evaluating a prototype • proposing improvements

Activities that illustrate applications of the technological problem-solving process and offer opportunities for "hands-on" experience in solving practical problems are provided in:

- Resource 7: How is a Technological Product Developed?
- Resource 8: Can I Make a Better Paper Airplane?

SUGGESTIONS FOR PLANNING PROBLEM-SOLVING ACTIVITIES

Themes developed in this manual provide opportunities for students to solve practical problems involving science and technology in a variety of meaningful contexts. Students should recognize that the strategies and skills they use in solving technological problems are "lifetime tools" and, when chosen according to purpose and need, are useful in a variety of everyday situations.

The following suggestions may be useful in planning problem-solving activities throughout the science program.

- Share the problem-solving model with all students. The model provides structure to the overall process as well as specific strategies/skills that might be used at each stage of the process. Familiarity with the model will increase the student's repertoire of strategies that can be utilized in solving a problem.
- Encourage students to be creative and experimental in their approach to problem solving. While useful in the structure it provides, the model for problem solving should not be interpreted as consisting of fixed stages and strategies. Its use will depend upon individual problems and individual students.
- Assist students to become aware of the thinking skills and thought processes that are useful in solving problems. Ask questions that encourage students to discover their own answers, and model (talk through) complete thought processes that are used in problem solving.
- Select problems that are relevant in the local community and that relate to the student's personal experience. Gather data related to relevant problems through a variety of methods.
  e.g.,
  - direct observation
  - reading/viewing
  - interview/discussion/debate
- Ensure that problem solving does not become tedious or unrealistically complex. Data related to the problem should be readily available. Remember that technology includes not just the "big things" that are the focus of societal issues, but also the "little things" that people do every day.
  e.g.,
  - how a bicycle or toy is repaired
  - how dishes are stacked for drying
  - how clothes are arranged in a closet or drawer

  Since these kinds of technologies are most relevant to students, include them in your instruction.
- Provide opportunities for students to learn from each other. Individual students often have knowledge of particular processes/devices and should be encouraged to share this knowledge with others.
- Research some important contributions made by Canadian scientists and engineers to the field of science and technology.
  e.g.,
  - What problem stimulated the scientist/engineer to do the work?
  - What problem-solving strategies were used to find a solution?
  - What is the domestic/international significance of this contribution?
- Arrange for a scientist/engineer from a local university/hospital/research station to visit the class and discuss:
  - the kinds of problems they solve
  - the strategies/skills they use in solving problems
- Encourage students to recognize how the model for solving problems in science provides a general plan for action that is also effective in guiding problem-solving efforts in English, mathematics, social studies and the occupational program, and how specific skills used at each stage within the model may vary according the nature of the problem.

RESOURCE 1: HOW DOES TECHNOLOGY AFFECT OUR EVERYDAY LIVES?

PURPOSE

To recognize how technology affects our daily activities.

PROCEDURE

1. Make a list of the products of technology that you encounter:
   - on the way to school in the morning
   - during the school day
   - during after-school activities
   - at home in the evening.
2. Classify your products according to human needs such as:
   - water
   - food
   - shelter
   - transportation.
   - communication
   - health
   - recreation

RESULTS

A typical list of technological products might look like the following:

Group	Products
water	running water (especially hot water for bathing)
food	frozen and canned foods, snacks, milk and ice cream, fresh vegetables, toaster, stove, refrigerator, microwave oven
shelter	furnace, house, electric blanket
transportation	cars, buses, subways, trains, roads, traffic lights
communication	radio, books, television, pens and pencils, paper, telephone, movies, microcomputer
health	toothpaste, vitamins
recreation	sports equipment, stereo systems, games

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RESOURCE 2: HOW FREQUENTLY DO I MAKE CHOICES ABOUT TECHNOLOGY?

PURPOSE

To illustrate the many technological processes or products a person chooses among in a typical day.

PROCEDURE

1. On a chart like the one shown, make a list of the activities you engage in over the course of a day. Describe the choices of technology available to you in doing each activity, and your actual choice.

Activity	Choices Available	Your Choice
brushing teeth	manual toothbrush/ electrical toothbrush	
drying hair	hair dryer/towel and air	

2. Answer the following questions;
   a. How many technological devices do you use in a day?
   b. How many activities offer no choice of alternative technological devices? One choice? Two choices? Three or more choices? Make a bar graph of this data.
   c. Would you say that technology offers you increased choices in your life? Why or why not?

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RESOURCE 3: HOW ARE SCIENCE AND TECHNOLOGY DIFFERENT?

PURPOSE

To distinguish between science and technology.

MATERIALS

Collect pictures and/or descriptions of people engaged in science or technology. Suggested pairs of pictures showing people engaged in science and technology include:

SCIENCE	TECHNOLOGY
Galileo observing motion of objects rolling down an inclined plane.	Young people coasting downhill in a soap box racer.
A chemist heating a test tube over a bunsen burner.	Someone using a stove to heat food.
A microbiologist looking through a microscope.	A doctor or nurse immunizing a patient against disease.

PROCEDURE

1. Show pictures or read descriptions to students. Are the people pictured or described engaged in science or technology? Use student responses to discuss the relationship and difference between science and technology.

   Use the pictures/descriptions to make a bulletin board display. Classify each situation as "science" or "technology".

2. Ask students to collect additional pictures or write their own descriptions of people engaged in science or technology. Encourage students to share these with the class and add them to the bulletin board display.

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RESOURCE 4: WHAT DO ENGINEERS AND SCIENTISTS DO?

PURPOSE

To provide concrete examples of how an engineer and a scientist solve problems.

PROCEDURE

A. Invite one or two engineers to speak to the class about the work they do. It is helpful if the engineers are working on a project that is of interest to students, such as a new product students might use. (An engineer can be located through local industry, or a student's parent may be an engineer.)

B. Provide the engineers with information on what the class is studying, including the problem-solving model. Remind the engineers of the students' grade level and ask them to use a problem they are working on to illustrate the problem-solving model. Encourage the engineers to bring some physical representations of the problem, such as the design and the prototype.

C. Several days before the class visit, ask students to make a list of questions they would like to ask the engineers. Appoint one or two students to act as hosts/hostesses and to introduce the guest speakers.

D. Repeat A-C by inviting one or two scientists to speak to the class about how they use inquiry and problem solving.

E. Discuss the similarities and differences between engineers and scientists. Are their work roles totally separate? Is there overlap between what they do?

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RESOURCE 5: WHAT IS THE SCIENTIFIC BASIS FOR TECHNOLOGY?

PURPOSE

To identify the scientific concepts that are associated with technological devices or processes.

PROCEDURE

Consider your list of technologies in Resource 1 or the list below. Discuss the scientific concept that each technological device or process is based upon.

Device or Process:

1. Pasteurization
2. Ball bearing
3. Barometer
4. Thermometer
5. Thermostat
6. Electric meter
7. Microscope
8. Solar Cell
9. Christmas tree lights
10. Hot air balloon

RESULTS

Scientific principles that govern the operation of the technologies listed above are provided below. Other lists can easily be made from the content of individual themes in the science program.

1. Heat kills bacteria.
2. Friction can be reduced by decreasing the area of surface contact.
3. The pressure of columns of different static fluids at the same level must be the same.
4. Most substances expand when heated.
5. Different substances expand by different amounts when heated.
6. Magnets exert a force on electric current.
7. Lenses refract light to focus images.
8. Electrons in solids can be excited to higher energy levels when they absorb light.
9. If enough heat is generated by passing an electric current through a filament, light is given off.
10. Archimedes' principle.

ALTERNATIVE ACTIVITY

Describe a scientific concept/principle and ask students to identify familiar technological devices/processes that demonstrate use of the principle.

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RESOURCE 6: WHAT IS A TECHNOLOGICAL SYSTEM?

PURPOSE

To distinguish among the components of a technological system.

MATERIALS

- bimetallic strip
- simple electric circuit
- light bulb
- heat source
- reference materials.

PROCEDURE

A. Demonstrate what happens to a bimetallic strip when it is heated.

B. Connect the bimetallic strip into an electrical circuit containing a light bulb. Using the electric circuit as an analogy, ask students how the bimetallic strip regulates temperature when used in a thermostat.

C. How do a thermostat and furnace comprise a technological system? Use a diagram to show how their relationship can be represented in terms of input, processing, output, feedback and comparison/control.

D. Ask students to use reference materials and to survey the appliances in their homes to determine what other technological systems have thermostats. **Caution**: When surveying appliances, *do not* take them apart. Simply analyze how they work to determine if a thermostat is involved.

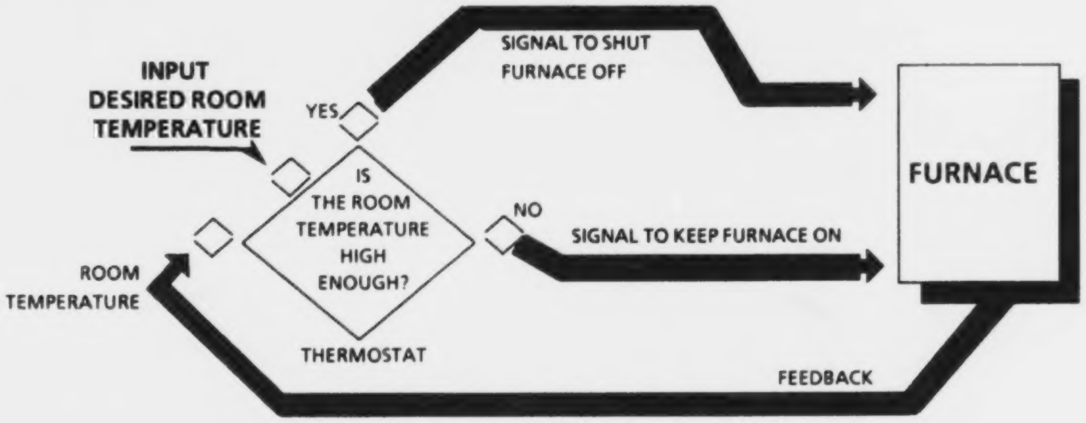
E. Ask students to consider an automobile and its driver as a system. What are the input(s), processes, output(s) and feedback associated with each of the following parts of the system: carburetor, engine, pistons and driver?

RESULTS

A bimetallic strip works in the following way: when heated, it bends and opens the circuit, and the furnace shuts off. Upon cooling, it straightens out and closes the circuit, and the furnace turns on.

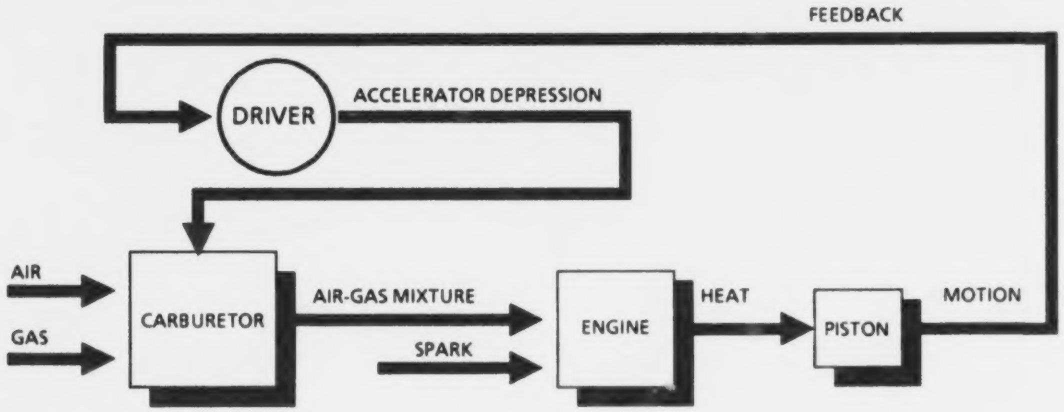
RESOURCE 6: WHAT IS A TECHNOLOGICAL SYSTEM? (cont'd)

A typical student diagram of the thermostat-furnace system might look like this:


SIGNAL TO SHUT FURNACE OFF
INPUT DESIRED ROOM TEMPERATURE
YES
IS THE ROOM TEMPERATURE HIGH ENOUGH?
NO
SIGNAL TO KEEP FURNACE ON
FURNACE
ROOM TEMPERATURE
THERMOSTAT
FEEDBACK

The components of the driver automobile system are show in the table and diagram below.

PART	INPUT	PROCESS	OUTPUT	FEEDBACK
carburetor	air and gas	mix air and gas	air-gas mixture	motion of car
engine	air-gas mixture and spark	combustion	heated gas	–
pistons	heated gas	response to heated gas	motion	–
driver	motion of car	decide on changes in speed	accelerator depression	car speeds up


FEEDBACK
DRIVER
ACCELERATOR DEPRESSION
AIR
GAS
CARBURETOR
AIR-GAS MIXTURE
SPARK
ENGINE
HEAT
PISTON
MOTION

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RESOURCE 7: HOW IS A TECHNOLOGICAL PRODUCT DEVELOPED?

PURPOSE

To illustrate that fairly uniform steps are followed in developing a technological product.

MATERIALS

Library reference books and magazines.

PROCEDURE

A. Divide the class into groups of three students each. Ask each group to choose one of the following technological products:

- airplane
- automobile
- bicycle
- electric motor
- radio
- television
- telephone
- light bulb
- microcomputer
- stereo.

B. Using library resources, have each group research the development of its chosen product and answer the following questions.

1. What need was the product designed to fulfil?
2. How did the idea for the product first come into the mind of the inventor(s)?
3. What kind of research was done before the product was developed?
4. What were the main features of the product's design?
5. Describe the prototype or initial form of the product that was constructed.
6. How was the prototype tested?
7. In what ways was the prototype modified before the product was mass produced?

C. Ask each group to report its findings to the class and respond to other students' questions.

RESULTS

Students should realize that most technological products are developed using methods that are quite fundamental to problem solving.

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RESOURCE 8: CAN I MAKE A BETTER PAPER AIRPLANE?

PURPOSE

To develop and use technological problem-solving skills.

MATERIALS

paper
reference books
safety glasses

PROCEDURE

1. Working in groups of three to four, use problem-solving skills to design and produce paper airplanes.

   a. **Identify the need or problem:**
   What is the problem you want to solve or need you want to meet? Examples might include:

      - Is there an accurate way to get wastepaper into a wastebasket?
      - How can we make a device that will stay in the air the longest?
      - What device will fly the furthest distance?

   b. **Develop a plan or idea:**
   Discuss ways to solve your problems (e.g., getting paper to a wastebasket by folding it into a shape like an airplane is a possible idea).

   c. **Research the plan or idea:**
   What additional information do you need? (e.g., What type of paper is best? What plans have others developed?)

   d. **Develop a design:**
   Based on the principles of flight, design an airplane to solve your problem or meet your need.

   e. **Build a prototype:**
   Build the airplane from your design.

   f. **Test the prototype:**
   Decide what tests you will use on your prototype. Carry out the tests and keep accurate records. (e.g., How many times did the airplane go into the wastebasket?)

   g. **Evaluate the prototype:**
   How well did the prototype perform? (e.g., Did it consistently hit the wastebasket?) Can its performance be improved by redesign? If so, redesign it.

h. **Acceptance and production:**
If the prototype is accepted (with or without redesign) it is then ready for production. If the prototype is rejected, you may wish to go back and start again at (b).

2. Answer the following questions:

   a. When problem solving is used in industry and business, who identifies the need or problem? Who evaluates the product?

   b. Are consumers ever involved in need identification? In evaluation?

NOTE: At the end of this activity, an airplane-flying contest can be held for each problem identified by students. The contest can be compared to market competition where planes are examined for their design superiority.

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SCIENCE, TECHNOLOGY AND SOCIETAL ISSUES

Science and technology influence many issues that we deal with individually and as members of society. Societal needs and concerns often influence technological problem solving and scientific inquiry. The science program must develop an understanding of the interactions among science, technology and society, and encourage students to appreciate the contributions and limitations of scientific and technological knowledge in resolving societal issues. Students should become familiar with the decision-making process and gain experience in its use by examining relevant issues in the local community that involve science and technology.

Learning activities used throughout the science program should enable students to demonstrate an understanding that:

- science and technology have impact on our lifestyle, occupational choice, environment and welfare
- technological products and processes develop in response to societal needs and wants
- economic, political and ethical perspectives often interact with science and technology and exert significant influence on each
- often the products of science and technology are accepted and used by society before the full extent of benefits/problems resulting from their use can be fully known
- scientific, technological and societal aspects of an issue help to inform the societal decision-making process
- compromises are often needed in order to arrive at workable solutions involving science and technology in society.

Issues selected for investigation throughout the science program should provide opportunities for students to:

- appreciate the need for informed decision making at both personal and societal levels
- develop confidence in using scientific and technological knowledge to inform personal decision making
- appreciate the legitimacy of many different perspectives in the decision-making process
- respect the perspectives and viewpoints of others
- realize that the solution to one problem may result in the creation of another problem
- appreciate the beauty and complexity of living things
- appreciate the interdependence of life forms
- appreciate the need for conservation of our environment.

A variety of teaching and learning strategies that illustrate how science and technology influence and are influenced by societal issues have been included in this section of the manual. The suggestions support active involvement in the decision-making process, and focus attention on:

- Interactions Among Science, Technology and Society
  - Recognizing How Science and Technology Influence Society
  - Recognizing How Society Influences Science and Technology.
- A Model for Making Informed Decisions .
- Suggestions for Examining Relevant Community Issues.

INTERACTIONS AMONG SCIENCE, TECHNOLOGY AND SOCIETY

RECOGNIZING HOW SCIENCE AND TECHNOLOGY INFLUENCE SOCIETY

We live in a rapidly changing society that is highly dependent upon science and technology. In fact, our world changes so rapidly that we sometimes fail to recognize that much of what we now take for granted existed only in the imaginations of people a few decades ago. Advances in science and technology will make much of today's science fiction become reality within our lifetime. Furthermore, the changes that we experience and have become accustomed to are occurring at an increasing rate. It is predicted that these changes will continue and accelerate as we enter the twenty-first century.

CLARIFICATION/EXAMPLE

Developments in Science and Technology That Influence Society

- New biomedical advances make it possible to replace defective hearts, kidneys and other organs.
- The first flight lasted only a few seconds. Now, a little more than half a century later, space vehicles travel thousands of miles an hour to explore distant planets.
- Nuclear technology, of interest a few years ago because of its destructive potential, could soon provide us with almost limitless supplies of energy for peacetime needs.
- Computer technology has made it possible to solve, in seconds, problems that only a decade ago required many human lifetimes.
- Science and technology may, in the future, make it possible for us to control weather and other natural phenomena to varying degrees.

The science program should provide opportunities for students to recognize the impact of science and technology on the nature of their lifestyle, their employment and career opportunities, as well as the quality of their environment. The activities that follow suggest ways of demonstrating how science and technology influence individuals and society within various themes of the science program.

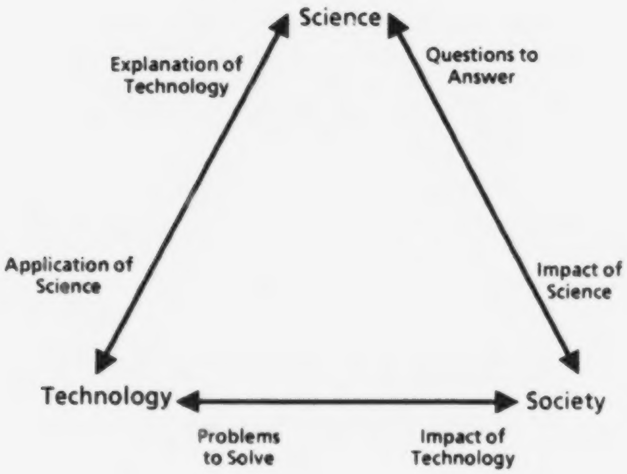
- Ask students to identify situations in which a particular technology has:
  - improved their lifestyle
  - had a negative effect on their quality of life

  Structure discussion and guide students through the processes of analysis and critical thought by using a "PMI" or a "CAF" (see Communication Skills, "Using Critical Thinking Skills").

  Activities provided in Resource 1: What Were the "Good Old Days" Really Like? and Resource 2: How Have Our Choices in Leisure Activities Changed? may be useful in examining the positive and negative effects of science and technology on society.

- Identify a familiar development in the area of science, technology or society. Ask students to predict possible effects of this development on the other two areas.

  Encourage students to recognize how science, technology and society are each part of an interdependent system, and how science and technology play a major role in society.



Activities that focus attention on how changes in either science, technology or society affect the other two areas are provided in Resource 3: How Do Science, Technology and Society Affect Each Other?

- Investigate the effects of technology on employment and career opportunities within each theme of the science program. Ask students to identify employment and career opportunities that:
  - have been created by technological change in the past ten years
  - have been modified by technological change in the past ten years
  - have become obsolete due to technological change in the past ten years.

  The activities provided in Resource 4: How Have Jobs and Careers Changed in the Last Thirty Years? and Resource 5: Where Are the Jobs and Careers? will assist students to understand how science and technology have affected business, industry and employment.

RECOGNIZING HOW SOCIETY INFLUENCES SCIENCE AND TECHNOLOGY

Science and technology do not act independently of society. Although the achievements of science and technology exert considerable influence on society, so does society either support or limit the progress of science and technology. Societal needs and concerns often initiate or direct technological problem solving and scientific inquiry. As societal values and attitudes change, so may motivation and support for research and development in particular areas change.

Learning activities should focus attention on how society influences science and technology at appropriate times throughout the science program, and should enable students to recognize that:

- technological processes and devices are usually developed in response to the needs of individuals and society

  e.g.,
  - vaccines against diseases
  - fast food restaurants
  - facsimile machines

- the use of a technological process or device may depend upon the attitudes of individuals or society toward it
  e.g., – food products such as the "chicken hot dog"
  – the recumbent bicycle
  – front-wheel drive automobiles
- society often influences science and technology through the public funds it provides to support research and development in certain areas
  e.g., – space exploration
  – medical research
  – environmental research.

Sample activities that illustrate how society influences scientific research and technological development are provided in:

- Resource 6: Would You Eat Irradiated Food?
- Resource 7: Have We Accepted Unit Pricing and Generic Goods?
- Resource 8: Why Are Some Inventions Not Accepted by Society?

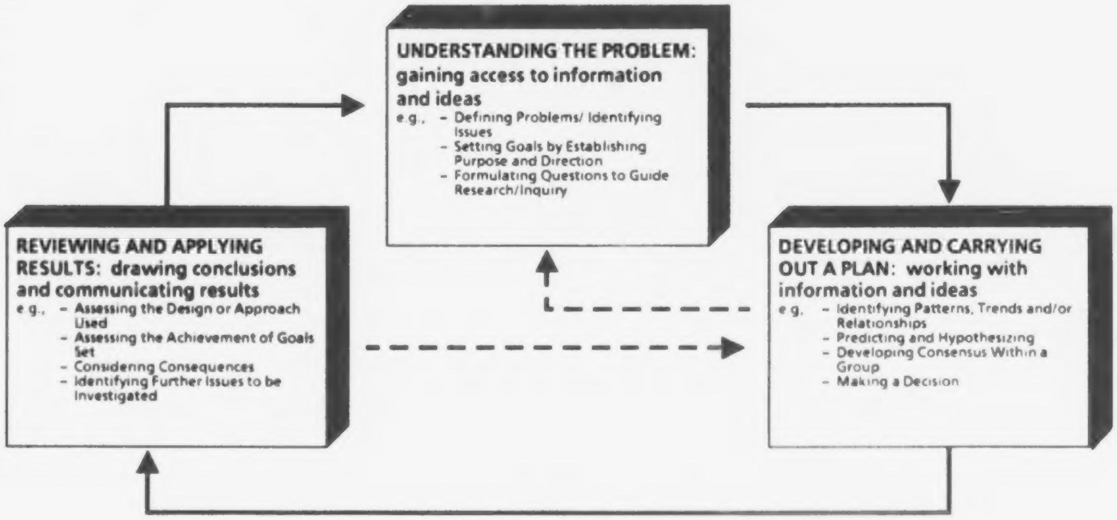
A MODEL FOR MAKING INFORMED DECISIONS

Although science and technology give us tremendous ability, individuals and society must assume the responsibility of using this ability wisely. Some developments in science and technology, if inappropriately used, may force us to pay a price in terms of their effect on society and the environment. For example:

- the world's natural resources are being rapidly depleted
- our water and air are no longer pure and clean
- thousands of plant and animal species are threatened with extinction.

This does not imply that we should try to halt scientific and technological advancements. Rather, it draws attention to the importance of the decision-making process and the role of choice in resolving related problems in society. Issues influenced by science and technology need to be examined within the context of choosing the most appropriate actions for existing circumstances. Resolving these issues involves considering alternative proposals for action and evaluating their consequences. Scientific and technological knowledge can help inform deliberation about these proposals.

The science program should provide opportunities for students to examine relevant societal issues that involve science and technology, and to develop a process for resolving these issues and making informed decisions. A model for resolving societal issues is suggested below. This model provides a starting point and some ways of organizing thought and action.


UNDERSTANDING THE PROBLEM: gaining access to information and ideas
e.g., – Defining Problems/ Identifying Issues
– Setting Goals by Establishing Purpose and Direction
– Formulating Questions to Guide Research/Inquiry
REVIEWING AND APPLYING RESULTS: drawing conclusions and communicating results
e.g., – Assessing the Design or Approach Used
– Assessing the Achievement of Goals Set
– Considering Consequences
– Identifying Further Issues to be Investigated
DEVELOPING AND CARRYING OUT A PLAN: working with information and ideas
e.g. – Identifying Patterns, Trends and/or Relationships
– Predicting and Hypothesizing
– Developing Consensus Within a Group
– Making a Decision

Specific actions identified at each stage of the decision-making process represent possible strategies that might be used in deliberating and making a decision to act in a certain way. Students may not always use each stage of the process and will select only those actions that are appropriate to purpose and ability. Students should, however, recognize decision making as a series of interrelated actions that lead to a defensible outcome.

By helping students to become aware of the thinking skills and thought processes that they and others use, students will be better able consciously to select and use those strategies and skills that are appropriate to the situations they encounter. Teachers are encouraged to:

- model (talk through) the processes and skills that are appropriate to analyzing a particular issue
- discuss the processes and skills that students are presently in the habit of using
- coach students in developing additional strategies that will structure and support the thought process.

This model for decision making can be explicitly presented to students as an overall process and then used as a teaching and learning model when analyzing societal issues. The chart that follows suggests student activities that may be appropriate at each stage of decision making represented in the model.

UNDERSTANDING THE PROBLEM	● identifying issues ● identifying/interpreting relationships ● asking questions ● identifying different perspectives or points of view (e.g., economic, political, ethical, scientific, technological).
DEVELOPING AND CARRYING OUT A PLAN	● researching issues – identifying alternatives – examining different perspectives on each alternative – gathering information about alternative technological products/processes related to an issue – identifying/applying appropriate scientific knowledge ● reflecting and deciding – considering the consequences/implications of the alternatives – evaluating technological products/processes from different perspectives – evaluating the defensibility of an action – consensus building ● taking action.
REVIEWING AND APPLYING RESULTS	● evaluating the immediate effects of actions taken ● evaluating the long-term consequences of actions taken ● modifying actions to reduce or eliminate other problems ● justifying/defending actions taken ● evaluating the decision-making process.

As students investigate relevant societal issues involving science and technology, focus attention on:

- the probable long- and short-term consequences of particular technologies and/or actions
- strategies for assessing particular technologies and/or actions in terms of their advantages and disadvantages
- an awareness of various perspectives/possible solutions to complex issues.

Sample activities that provide opportunities for students to examine societal issues and develop skills appropriate to the decision-making process are provided in:

- Resource 9: How Should We Access a Technological Process or Device?
- Resource 10: Who Receives an Organ Transplant?
- Resource 11: How Do We Make Decisions About Technology?

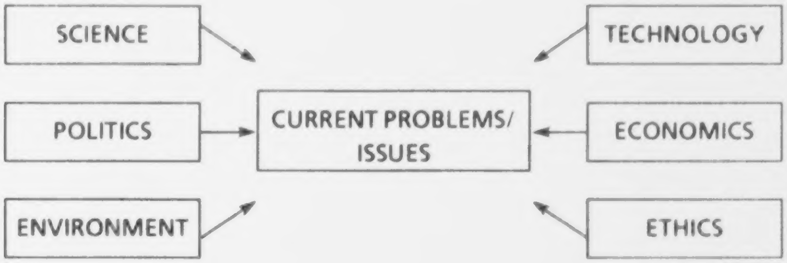
SUGGESTIONS FOR EXAMINING RELEVANT COMMUNITY ISSUES

Themes developed in this manual provide opportunities for students to investigate relevant issues involving science and technology in the local community. Students should recognize that the strategies and skills they use in making informed decisions are "lifetime tools" and, when chosen according to purpose and need, are useful in many everyday situations.

The following suggestions may be useful when analyzing local issues involving science and technology.

- Share the decision-making model with all students. The model provides structure to the overall process as well as specific strategies/skills that might be used at each stage of the process. Familiarity with the model will increase the student's repertoire of strategies that can be utilized in resolving issues.
- Encourage students to be flexible in their approach to decision making. While useful in the structure it provides, the model should not be interpreted as consisting of fixed stages and strategies. Its use will depend upon individual issues and individual students.
- Make students aware of the thinking skills and thought processes that are useful in analyzing issues. Ask questions that encourage students to discover their own answers and model (talk through) complete thought processes that are used in resolving issues and making informed decisions.
- Select issues that are relevant in the local community and that relate to the student's personal experience. Gather data related to relevant issues through a variety of methods.
  e.g.,
    - direct observation
    - reading/viewing
    - interview/discussion/debate

  Ensure that students consider current perspectives on the issues they investigate by using the local media (e.g., newspaper, periodicals, television, radio).
- Encourage students to consider advantages and disadvantages associated with the issues they investigate and to avoid taking simple "for" and "against" positions. Students should recognize that there are often several ways to resolve complex issues. The model below illustrates the complexity of some issues and offers a useful framework for their examination from different perspectives.



- Structure discussion and debate using the guidelines provided in Communication Skills, "Strategies for Discussing and Debating". Debating is a good technique to use in encouraging students to think through complex issues carefully. Deal appropriately with students who may dominate conversation and encourage others who are hesitant to express their ideas; to become involved. Ensure that discussion does not become a clash of personalities.

- Ask questions that will challenge students to use higher-level reasoning skills and to explore ideas they may not have considered. Useful types of questions include:
  - Can you tell me more about ...?
  - What else might happen if ...?
  - If ... then ...?
  - How did you arrive at that conclusion?
  - What made you ask that question?
  - Why do you say that?
  - How did you think of that?

- Provide opportunities for students to clarify their ideas and justify the positions they adopt through writing activities. Guidelines for structuring writing activities are provided in Communication Skills, "Summarizing, Evaluating and Communicating Ideas in Science".

- Encourage students to recognize how the model for examining issues in science provides a general plan for action that is also effective when examining other kinds of issues in English, mathematics, social studies and the occupational program, and how specific skills used at each stage within the model may vary according to the nature of the issue.

The following chart provides a comparison of the scientific, technological and societal processes as they occur in practical situations.

	SCIENCE	**TECHNOLOGY**	**SOCIETY**
TYPE OF ACTIVITY:	Theoretical	Practical	Practical
PROBLEMS ARISE FROM:	Curiosity about events and phenomena in the natural world	Wants/needs of individuals and society to accomplish specific tasks	Consideration of a broad range of interests in terms of the "common good"
RELATED QUESTIONS:	• Why does ...? • How do we know that...?	• What can we do to ...? • Will it work?	• What alternatives and consequences are there? • What should we do?
STRATEGY:	Scientific Inquiry	Technological Problem Solving	Deliberation/Consensus Building
OUTCOMES/ SOLUTIONS:	Knowledge about natural phenomena	Products and processes designed to achieve intended purposes	A defensible decision in the particular circumstances
EXAMPLES:	Why does milk sour? (Bacteria grows in milk. This bacterial growth causes illness and also causes milk to sour.)	What can we do to keep milk from souring and causing illness? (The process of pasteurization makes milk safe to drink and produces milk that tastes good.)	Should we require standards for the processing and handling of milk? (All commercial milk supplies must be pasteurized. The containers must be dated.)

RESOURCE 1: WHAT WERE THE "GOOD OLD DAYS" REALLY LIKE?

PURPOSE

To illustrate that science and technology have changed society and our lifestyles a great deal in the past century.

MATERIALS

Reference books.

PROCEDURE

1. Work in groups of three. With the help of reference books, your teacher and other adults, answer the following questions:

    a. Using the fastest transportation available, how long would it have taken you to reach Toronto, Ontario in 1889? How long would it take you today?

    b. How quickly would you have been able to contact a relative living in Vancouver, B.C. in 1889? How long would it take today?

    c. What would you have used to go shopping in a town ten kilometres from your home in 1889? What would you use today? How long would a round trip have taken in 1889? How long would it take today?

    d. What might you have done to entertain yourself in 1889? For how many hours per week would you have been engaged in such leisure in 1889?

    e. What might you do to entertain yourself today? For how many hours per week would you engage in such leisure today?

    f. How many years would you have expected to live in 1889? How many years do you expect to live today?

    g. What diseases that might have threatened you in 1889 have been virtually eliminated as threats today?

    h. What careers might you pursue today that were not available to you in 1889?

2. Review and compare group responses to the above questions in class. Summarize your discussion with the following questions:

    a. In what ways have our lives been made better by achievements in technology over the last century?

    b. What good things have been lost through the impact of technology over the past century?

RESOURCE 1: WHAT WERE THE "GOOD OLD DAYS" REALLY LIKE? (cont'd)

RESULTS

Students, in comparing the possibilities in 1889 and today, will realize that vast improvements have occurred in transportation, communication, health care and personal opportunities. However, some may realize that such progress has come at the expense of the environment, national security and the extended family. The key concept is that science and technology invariably change society.

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RESOURCE 2: HOW HAVE OUR CHOICES IN LEISURE ACTIVITIES CHANGED?

PURPOSE

To show that technology has greatly increased the number of ways we can spend our leisure time.

MATERIALS

Reference books.

PROCEDURE

1. Make a list of the ways you can spend your leisure time (e.g., after school, evenings, weekends).
2. Place a check next to the ways which were also available to your parents when they were your age.
3. Place a second check next to the ways which were available to your grandparents when they were your age.
4. Place a third check next to the ways which were available to the earliest settlers in Canada.
5. Place an asterisk in front of the ways which depend on technology.
6. Observe some relationships between the asterisks, check marks and activities in your list.

RESULTS

Student lists may look like the following:

*	✓			Television
*	✓	✓		Movies
*				Video games
*	✓	✓	✓	Visit with friends
*				Watch movies at home on the VCR
*	✓	✓	✓	Eat
*	✓	✓	✓	Read
*	✓	✓	✓	Play games (non-video)

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RESOURCE 3: HOW DO SCIENCE, TECHNOLOGY AND SOCIETY AFFECT EACH OTHER?

PURPOSE

To show that changes in either science, technology or society also affect the other two areas.

PROCEDURE

Ask your students to suggest situations in which changes in science have affected technology and society and also situations in which changes in society have affected science and technology. If they encounter difficulty, you might offer hints from the examples below.

CHANGES IN SCIENCE THAT HAVE AFFECTED TECHNOLOGY AND SOCIETY:

SCIENCE	TECHNOLOGY	SOCIETY
laws of motion	space travel	new products, greater knowledge of universe
electricity	electrical appliances	more leisure time
electromagnetic waves	radio and TV	home entertainment
chemistry (chemical bonds)	synthetic materials	new products
radioactivity	nuclear medicine	better health
nuclear fission	nuclear reactors	reduced dependence on oil
structure of matter	microelectronics	increased calculative capability

CHANGES IN SOCIETY THAT HAVE AFFECTED SCIENCE AND TECHNOLOGY:

SOCIETY	SCIENCE	TECHNOLOGY
funding of medical research	medical research	new diagnostic techniques
prohibition of genetic engineering laboratories	restricted research	slow technological development

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RESOURCE 4: HOW HAVE JOBS AND CAREERS CHANGED IN THE LAST THIRTY YEARS?

PURPOSE

To investigate changes in business, industry, career choices, and employment brought about by science and technology.

PROCEDURE

1. Interview a retired person and ask the following questions. Record the answers.

   a. What was your first full-time job?
   b. How long did you continue to do that type of work?
   c. If you changed the type of work you did, what was the reason?
   d. How many different types of work did you do?
   e. Of all the types of work you did, how many of those jobs are still available today?
   f. What has replaced the jobs no longer available?

2. Interview someone who has been working in the same job at least ten years and ask the following questions. Record the answers.

   a. What changes have you seen in your job in the past ten years?
   b. Have computers affected your job?
   c. What changes do you expect to see in your job in the next ten years?

3. Interview a person who has been employed full-time for less than ten years and ask the following questions. Record the answers.

   a. Was your job newly created by some technological advance or was it performed by someone else before you?
   b. Do you use computers on your job?
   c. What changes do you expect to see in your job in the next ten years?

4. Tabulate class results.

   Retired persons:

   - Number with same type of job entire life _ .
   - Number with two different types of jobs _ .
   - Number with more than two different types of jobs ___ .
   - Total number of types of jobs _.
   - Number still available today ___.

   Persons working ten years:

   - Number of changes in jobs in the last ten years ___ .
   - Number affected by computers ___ .
   - Number with changes in jobs expected in the next ten years ___ .

RESOURCE 4: HOW HAVE JOBS AND CAREERS CHANGED IN THE LAST THIRTY YEARS? (cont'd)

Persons working less than ten years:

- Number of jobs newly created by a technological advance ___________.
- Number of jobs previously performed by someone else _____________.
- Number of jobs using computers _________________________________.
- Number with changes in jobs expected in the next ten years _________.

5. Plan a field trip to industries that are utilizing new technological devices or processes. If possible, select a company that has an employee "retraining" program. Observe the work people are doing.

6. Write a brief paragraph describing your observations in question 5.

7. Look at the class data from question 4 and your raw data from questions 1, 2 and 3. Write two or three paragraphs that summarize how science and technology have affected business, industry, career choices and employment in the last 30 years.

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RESOURCE 5: WHERE ARE THE JOBS AND CAREERS?

PURPOSE

To use newspaper classified sections to see what jobs and careers are available and what training is necessary for them.

MATERIALS

Classified sections from local and large city newspapers.

PROCEDURE

1. From the classified sections of the newspapers, cut out ten "Help Wanted" ads.
2. Describe the training necessary to obtain each of the jobs.
3. As a class, discuss the following questions:
    a. How can an individual obtain the training necessary to obtain or change jobs?
    b. What can students do to prepare for a changing job market?
    c. Which of the jobs or careers interest you most? Why?

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RESOURCE 6: WOULD YOU EAT IRRADIATED FOOD?

PURPOSE

To illustrate that acceptance of a technological process or device depends on the attitudes of individuals toward it.

MATERIALS

Newspaper and magazine articles on irradiated foods.

INTRODUCTION

Everywhere in the world, we throw away large amounts of food every day because the action of microorganisms has caused the food to become moldy or rotten. If we used ionizing radiation on these foods to kill the microorganisms, the loss of food would be significantly reduced. But the use of ionizing radiation in Canada is controversial, even though other countries already irradiate food.

PROCEDURE

1. Read the following passage:

   There is cooked ham on the table in the food-testing laboratory. It has been there for two months covered only by a piece of plastic wrap. It looks as if it had just come out of the oven but it is not hot. There is a note next to it which says it was irradiated 52 days ago. The note also indicates that the ham was part of a test on preserving food by radiation and that the ham has been in the same spot ever since. The test has shown that the radiation has killed all the bacteria which could cause the ham to spoil but has not affected the taste of the ham or made it radioactive. You are invited to have some of the ham for lunch.

2. In a group of three or four, discuss and answer the following questions:

   a. How do you feel about eating the ham?
   b. Why do you feel that way?
   c. What questions would you ask the scientists who tested the ham before making your decision?

3. Have one member from each group report how the members of the group felt about eating the ham.

4. Read at least two articles on irradiated foods and take notes.

5. Write a report that summarizes the evidence for and against eating irradiated food. Include in your report a statement about whether or not you would eat irradiated food. Explain your decision.

RESOURCE 6: WOULD YOU EAT IRRADIATED FOOD? (cont'd)

RESULTS

Some of the evidence for and against eating irradiated food is cited below.

Evidence for:

- Studies over 30 years find the process safe if irradiation levels are controlled.
- Studies indicate that no radioactive residue results and there is no reduction in nutritional content of foods.
- Irradiation of food eliminates the need for chemical preservatives. (Some, like ethylene dibromide and nitrites, have been controversial in themselves.)

Evidence against:

- Some changes do occur in foods, producing new substances which may be harmful.
- Studies have not been conducted over a long enough time.
- Irradiation may increase aflatoxin, a suspected carcinogen.
- Government may not require the labelling of irradiated food.

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RESOURCE 7: HAVE WE ACCEPTED UNIT PRICING AND GENERIC GOODS?

PURPOSE

To show that the acceptance of a technological product/process depends upon the attitudes of individuals toward it.

PROCEDURE

1. Take a chart similar to the one provided on the following page to two different supermarkets. At each supermarket, examine the unit pricing on ten name-brand items and also a generic brand for each item. Where possible, include at least two package sizes for each item. Record the unit price on the chart as you examine each item.

2. Survey at random twelve shoppers from each supermarket. Ask the following questions:

   a. Do you use unit pricing in selecting what you buy?
   b. Do you buy generic goods? If so, do you feel that buying generic goods saves you money without sacrificing quality?

3. Summarize the results for the entire class. Answer the following questions:

   a. Which of the brands would you purchase in each supermarket? Why?
   b. Which supermarket appears to have better values?
   c. Does your survey of shoppers indicate that they use unit pricing while making their purchases?
   d. Do the shoppers at one supermarket seem more conscious of unit pricing than those at the other supermarket? If so, give a possible reason.
   e. Does your survey of shoppers indicate that they buy generic goods?
   f. Do the shoppers at one supermarket seem more conscious of generic goods than those at the other supermarket? If so, give a possible reason.

RESOURCE 7: HAVE WE ACCEPTED UNIT PRICING AND GENERIC GOODS? (cont'd)

ITEM	Name Brand		Generic Brand	
	Store #1	Store #2	Store #1	Store #2
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

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RESOURCE 8: WHY ARE SOME INVENTIONS NOT ACCEPTED BY SOCIETY?

PURPOSE

To consider why certain technological designs were never widely accepted.

PROCEDURE

1. Consider the following list of patented inventions:

    - a fake cigarette package that coughs loudly when picked up
    - children's forks and spoons whose handles are made into musical whistles
    - a beauty mask for women to wear at night while sleeping
    - parakeet diapers
    - a firecracker fire alarm
    - a golf ball that sends out a smoke signal when it lands to help locate it
    - a gun whose curved barrel extension allows it to shoot around corners
    - a coffin with a tube for fresh air and an alarm
    - an automatic baby-burper
    - a gold trap which, when swallowed, is supposed to catch tapeworms.

2. Discuss why each of the above inventions has not become widely accepted.
3. Suggest an invention that might be useful and describe it to the class.
4. Poll the class to determine which student inventions are most popular. Which appear to be most useful?

RESULTS

Each week, thousands of inventions are registered. Millions of patents have been issued since 1790. Clearly, many of these innovations were thought to be more important by their inventors than by the society which neglected to use them.

(Patented inventions were selected from Patents Ridiculous and Sublime by Stacy, V. Jones, Quadrangle/The New York Times Book Co., 1973.)

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RESOURCE 9: HOW SHOULD WE ASSESS A TECHNOLOGICAL PROCESS OR DEVICE?

PURPOSE

To develop a process for assessing a technological process or device.

PROCEDURE

1. Using the chart provided, describe the benefits and burdens placed upon people and the environment when each of the technological processes/devices are put into use in our society.
2. Place an asterisk in front of each technological process/device for which you feel the benefits outweigh the burdens. Be prepared to discuss your reasons.
3. How often did you and your classmates agree that a particular process or device should be (or should have been) adopted?
4. How can people assess whether or not to adopt a technological process/device?

DATA TABLE

Technological Process or Device	Benefit	Burden
nuclear energy	(additional electricity)	(risk of war, radioactive wastes)
mass transportation	(less pollution, less energy used)	(personal inconvenience, large cost)
robotics	(modernized, efficient industry)	(loss of jobs)
drugs	(treat diseases)	(dependence through abuse)
pesticide/insecticide	(increased agricultural yields)	(extinction of helpful species)
product packaging with synthetic materials	(fresher food)	(nonbiodegradable waste in landfills)
computers	(increased ability to process data)	(loss of jobs, health problems from video display terminals)
space travel	(increased knowledge)	(high financial cost)
life-sustaining devices	(keep people alive)	(how to decide when to use or remove them)
organ transplants	(increased life span)	(cost, decision as to who receives them)
automobile	(increased mobility)	(increased pollution, deaths)
chemical fertilizers	(increased agricultural yields)	(eutrophication of lakes)
artificial sweeteners	(convenience for diabetics and dieters)	(increased risk of cancer)

RESOURCE 9: HOW SHOULD WE ASSESS A TECHNOLOGICAL PROCESS OR DEVICE? (cont'd)

RESULTS

Indicated in parentheses. Students should begin to realize that it is possible to assess technological processes/devices by the burdens and benefits they create. However, assessment depends on an ability to predict future consequences. We do not always possess this ability. When a decision is made to adopt or reject a particular process/device, there may not be total agreement about that decision.

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RESOURCE 10: WHO RECEIVES AN ORGAN TRANSPLANT?

PURPOSE

To show the serious issues which may surround the use of a technological process.

MATERIALS

Recent newspaper and magazine articles about organ transplants.

PROCEDURE

1. Read several articles about organ transplants.

2. As a class, discuss the following questions:

    a. There are more patients in need of organ transplants than there are organs available. What is the fairest way of deciding who gets the organs that are available? Who should decide?
    b. If a person offered to sell a part of his or her body to someone in need of that part, should this be permitted?
    c. Organ transplant operations and related equipment and health care are very expensive and serve a relatively small number of people. What responsibility does government or society have for assuming the financial burden of these expensive procedures?
    d. A person can survive if only one of the two kidneys in the body is functional. Should it be legally required that parents or children contribute one of their healthy kidneys to another member of the family if that is required to save the person's life?

3. In your reading about organ transplants, what other issues did you find concerning transplants? Which of these are moral or ethical issues? Which are governmental or legal issues? Why?

4. Are the issues you have just discussed and read about easy to resolve? Why or why not?

RESULTS

Students should be encouraged to understand that there are different issues surrounding the use of many technological processes and devices. These issues are controversial and there are generally no easy solutions.

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RESOURCE 11: HOW DO WE MAKE DECISIONS ABOUT TECHNOLOGY?

PURPOSE

To show that a complex technological issue has several possible solutions and that trade-offs are often made among these solutions.

MATERIALS

Reference books and magazine, recent newspaper articles about technological issues.

PROCEDURES

1. Read several magazine and newspaper articles about one of the following technological issues:
    - the need for additional amounts of energy
    - disposal of toxic wastes
    - disposal of radioactive wastes
    - contamination of ground water supplies
    - artificial organs.
2. As a class, discuss and describe alternative courses of action for the technological issue.
3. As a class, decide which alternative courses of action should be followed. You may have to come up with a compromising course of action.
4. Answer the following questions:
    a. How difficult was it to make a group decision about the proper course of action?
    b. To what degree did individuals have to make compromises?
    c. If experts were to become involved in making decisions about this issue, from what disciplines might they come? To what extent do you think these experts would agree on the solution?
5. Invite a person who is involved with policy making to speak to the class about how individuals and government make decisions and set policy.

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COMMUNICATION SKILLS

The strands of language (i.e., listening, speaking, reading, writing and viewing) play an important part in the teaching and learning of science. Not only is language a means of communication, but it is also part of the thinking process used to combine ideas, find relationships, ask questions and solve problems. Language development in Science 16-26 must parallel its development in English 16-26, through use of strategies that are often similar to those used in the English class.

A variety of teaching and learning strategies useful in gathering, interpreting, recording, evaluating and communicating ideas in science are provided in this section of the manual. Teachers are encouraged to familiarize themselves with these strategies. By teaching and modelling appropriate "learning to learn" strategies within each theme of the science program, teachers can support students in their use of language and thinking skills.

CLARIFICATION/EXAMPLE

An Approach to Teaching a Learning Strategy (Deshler, 1979)[1]

1. Test students on a task that requires the use of the strategy to be taught. Discuss the results with students and point out strategy deficiencies.
2. Describe the steps involved in the target strategy. Details should include appropriate behaviours, their sequence and ways in which the strategy will help the student.
3. Model the strategy for students. Teachers should "think aloud" so that students can become aware of all processes involved in the strategy.
4. Ask students to "verbally rehearse" the strategy.
5. Provide opportunities for students to practise using the strategy through controlled activities. Use instructional materials that match the students' reading level.
6. Provide positive and corrective feedback to students as they apply the strategy.
7. Provide opportunities for students to apply the strategy using more difficult materials that are grade-appropriate.
8. Provide positive and corrective feedback to students as they practice applying the strategy to grade-appropriate material.
9. Retest students on their use of the strategy. Use the test given in Step 1 with different instructional materials.

The teaching and learning strategies provided on the pages that follow are similar to those used in developing communication skills in other subject areas, and focus attention on:

- Reading and Viewing Science Materials
  - A Study Guide for Reading in the Content Areas
  - Assessing the Readability of Science Materials
  - Comprehension Strategies
  - Developing Technical Vocabulary
  - Using Advance Organizers/Conceptual Overviews
- Summarizing, Evaluating and Communicating Ideas in Science
  - Making Summaries
  - Using Critical Thinking Skills
  - Giving and Following Directions
  - Strategies for Discussing and Debating
  - Informal Essay Writing.

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[1] Alley, Gordon and Deshler, Donald, *Teaching the Learning Disabled Adolescent: Strategies and Methods*, Love Publishing Co., 1979.

READING AND VIEWING SCIENCE MATERIALS

The precision of vocabulary and symbols used in science may be a source of difficulty for students. The everyday meanings associated with words often interfere with an understanding of the special meanings that words have in science. Each theme of the science program should be analyzed in order to identify demands relative to symbolic content. Discussion of common base words, prefixes and suffixes will assist students to identify/recall the meanings of technical words that are used. Consider the following questions when planning activities that provide for an understanding of technical vocabulary.

- How does this vocabulary relate to everyday usage?
- How does it conflict with everyday usage?
- How does it relate to previously studied science terms?

The role of experience in developing concepts must be recognized in vocabulary development activities. Definitions may be developed as summarizing statements of ideas that have been understood, but should not be used as introductions to new vocabulary or symbols. Encourage students to explain the meanings of new words in their own language, and to draw upon personal experience in giving examples of how the word is correctly used. The following instructional sequence will foster meaningful vocabulary development, and ensure that each word or symbol introduced becomes part of the student's active or "working" vocabulary.

- Discuss real life examples from the student's environment where the word/symbol might be used.
- Simulate concrete and transitional models where the word/symbol might be appropriately used.
- Discuss and list distinguishing characteristics of the word/symbol.
- Record the word/symbol and its distinguishing characteristics (meaning) in a personal science "glossary".

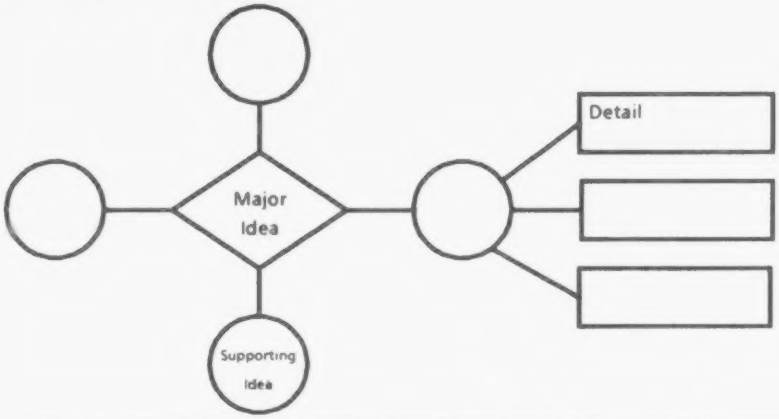
When reading and viewing science material for content, students must assimilate new material into their existing knowledge structure. Introductory questions and activities that focus attention on "what I already know" can prepare the student for reading material that provides answers to "what I need to know". Students can be guided in reading/viewing for content and information through activities that include the following steps.

- Decide on a purpose for reading/viewing. State the purpose as a question.
- Skim the whole section to get an idea of how it is organized.
- Notice various "aids to reading/viewing" that have been used in the material (e.g., headings, colour, bold print, diagrams, charts, coloured pages).
- After reflecting on purpose, decide which sections need intensive study and which may be delayed or skipped.
- Engage in "active" reading/viewing of the material (e.g., ask questions; think of examples; rephrase in everyday language).

Inquiry and problem solving often necessitate that relationships and patterns be identified through reading and viewing. Through discussion and related activities, teachers are encouraged to assist students in identifying major and supporting ideas, their relationships, and in making inferences/predictions on the basis of information gathered. "Semantic webs" and "concept circles" are useful in structuring comprehension activities, and can be used to help students organize, interpret and integrate information.

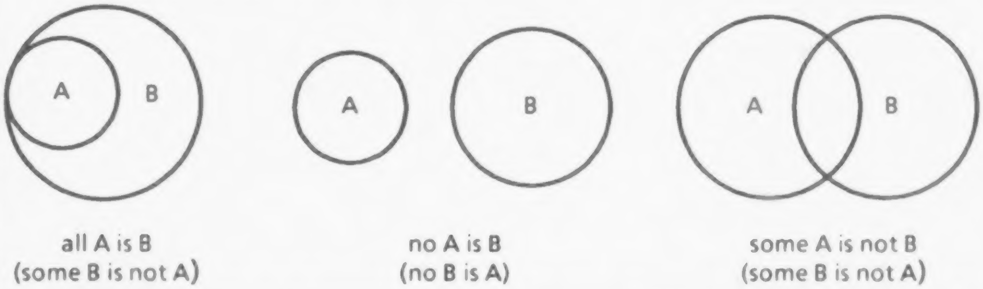
CLARIFICATION/EXAMPLE

A Simple Web Configuration


Detail
Major Idea
Supporting Idea

CLARIFICATION/EXAMPLE

Illustrating Relationships With Concept Circles


A
B
all A is B
(some B is not A)
A
B
no A is B
(no B is A)
A
B
some A is not B
(some B is not A)

Additional suggestions for developing reading and viewing skills in science class are provided in:

- Resource 1: A Study Guide for Reading in the Content Areas
- Resource 2: Assessing the Readability of Science Materials
- Resource 3: Comprehension Strategies
- Resource 4: Developing Technical Vocabulary
- Resource 5: Using Advance Organizers/Conceptual Overviews.

SUMMARIZING, EVALUATING AND COMMUNICATING IDEAS IN SCIENCE

Communication skills used in summarizing, evaluating and communicating ideas in science are similar to the skills required of students in other subject areas. Students should be given opportunities to describe relationships, patterns and the results of investigations that are undertaken through a variety of writing activities. The use of language can be strengthened through questions that probe for explanations rather than stimulate recall of information. Students should frequently be asked why, and be encouraged to use writing skills to express their ideas and interpretations.

CLARIFICATION/EXAMPLE

Questions That Involve Students in Investigation

- What are we looking for?
- What do we want to explain/investigate?
- What do you notice about this ...?
- What do you think might happen if ...?
- Why did ...?
- What should we do first?
- What is stopping us?
- If this is so, then ...?

Questions That Stimulate Creative Response

- What is my next step?
- How will I do that?
- How can I design a better ...?
- What is the relationship between ... and ...?
- Why did ... happen after ...?
- How would you design an experiment to ...?
- What might happen if you use ... instead of ...?
- What is the likelihood that ...?

Questions That Stimulate Analysis and Evaluation

- How did you know that ...?
- What does the data indicate?
- What caused ... to happen?
- How does ... apply to ...?
- How could you explain ... in another way?
- How might you use these results?
- How could we make our work easier another time?
- How could we improve it or make it better?
- What should we tell others?

A variety of writing activities should be used within each theme of the science program. These activities can provide for experience in:

- summarizing (e.g., note-taking)
- describing (e.g., recording observations)
- giving and following directions (e.g., logical sequencing)
- writing a laboratory report (e.g., writing directions/descriptions)
- informal essay writing (e.g., expressing an opinion, supporting a point of view).

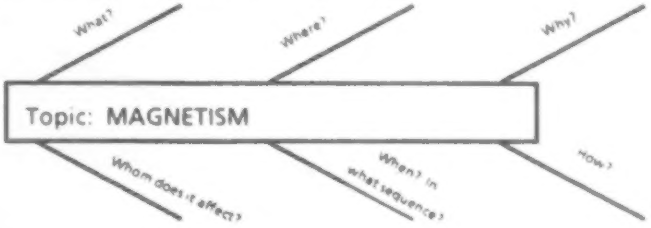
Of particular importance are skills in summarizing or note-taking because the way students record information in class can have a major effect on how well they process and remember it. Note-taking from books, lectures, visual presentations and laboratory experiments causes students to arrange and structure knowledge, enhances memory and also maintains attention during instruction. Although note-taking styles may vary according to purpose and ability, teachers can help students to develop and extend their note-taking skills by:

- modelling the use of appropriate note-taking styles. Show students how you would take notes.
- taking notes together with the class. Illustrate a note-taking process using a text reading, a filmstrip, or even an experiment. Compare and contrast your notes with those of the students.
- asking students to take their own notes while you closely monitor their work. Correct their mistakes when necessary.
- requiring students to take notes independently during class. Give assignments that require note-taking. Include a note-taking passage on each exam.

CLARIFICATION/EXAMPLE

A Note-Taking Style

In the "herring bone" style, a fish spine becomes a visual analogy to describe a specific scientific topic. Each bone holds a word that requires an explanation. Students may record very little information on one bone, and a lot of information on another bone. They may write above and below the bones.



- What? – What is magnetism?
- Where? – Where does it occur?
- Why? – Why does it work the way it does?
- Who? – Who is affected?
- When? – When does it work? In what sequence?
- How? – How does it work?

Additional suggestions for summarizing, evaluating and communicating ideas in science are provided in:

- Resource 6: Making Summaries
- Resource 7: Using Critical Thinking Skills
- Resource 8: Giving and Following Directions
- Resource 9: Strategies for Discussing and Debating
- Resource 10: Informal Essay Writing.

RESOURCE 1: A STUDY GUIDE FOR READING IN THE CONTENT AREAS

STUDY GUIDE

1. Suggest a different title for the article you have just read. Try to capture the essence of the article in your title, but keep it short.

2. Two key ideas or concepts discussed in this article are:
   - ________________________________
   - ________________________________

3. Three details or facts you would like to remember from this article are:
   - ________________________________
   - ________________________________
   - ________________________________

4. What did you find especially interesting or surprising in the article?

5. What word or words from this article do you think the author chose rather carefully?

6. Indicate any words, sentences or paragraphs in the article you would like to discuss in class or have explained:

   Page: ______________ Line: ______________

7. If you could talk to the author of this article, what questions would you ask or what comments would you make to him or her?

8. What mental images did you form while you were reading this article?

9. Rate this article by marking an X on the line at the point that indicates your evaluation.

   Very ◄────────────────────► Not very

Interesting: ________________________________

Informative: ________________________________

Easy to Read: ________________________________

This study guide by Smith[1] can be modified to suit the needs and abilities of students, the characteristics of the reading assignment and the instructional objectives. Note that the type of questions asked of students does not permit simply scanning the selection to find answers. Students enjoy sharing their responses in small groups or through class discussion.

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[1] Smith, Richard J., *A Study Guide for Extending Students' Reading of Social Studies Material*, The Social Studies Vol. 78, No. 2, pp. 85-87.

RESOURCE 2: ASSESSING THE READABILITY OF SCIENCE MATERIALS

Teachers are encouraged to supplement textbook activities with appropriate articles and materials from other sources. In assessing the overall readability of these materials, it is important to recognize factors that may contribute to the ease or difficulty with which students can read and comprehend the material. Reading involves complex interactions between student and text.

Student-related considerations include:

- background knowledge/preparedness for the reading task
- motivation
- interest.

Text-related considerations include:

- vocabulary (e.g., level of difficulty, word length, jargon, technical language)
- conceptual depth
- syntax (e.g,. sentence structure)
- format (e.g., margins, bold type, italics, headings, underlinings)
- organization (e.g., chapter summaries, pre- and post-questions, word lists, glossaries)
- key visuals (e.g., pictures, charts, graphs, tables).

Acknowledging and making necessary adjustments to the student- and text-related considerations listed above will result in a supportive, appropriately challenging reading environment in science. Readability data should be used to alert teachers to areas of possible difficulty and the need to provide reading comprehension aids.

READABILITY FORMULAS: SMOG AND FRY

Readability formulas generally reflect text difficulty in terms of the length of sentences and words. Formulas provided for use by the teacher include:

- the SMOG Formula
- the Fry Readability Graph.

These formulas can be used in conjunction with other methods of assessing the appropriateness of reading materials in science.

THE SMOG FORMULA

This formula, described by McLaughlin (1969) as a "simple measure of gobbledegook", is a simple technique:

1. Near the beginning of the text, count 100 consecutive words; then count 100 consecutive words in the middle and 100 near the end of the text (approximately five sentences in each section).

2. Tabulate the number of words consisting of three or more syllables. If a word is repeated it should be included in the count.

3. Determine the square root of the number of the polysyllabic words that have been counted. McLaughlin suggests that this be done by taking the square root of the nearest perfect square. If the count lies roughly between two perfect squares, choose the lower number.

4. Finally, add 3 to the estimated square root. The resulting number will give an estimate of the reading level a student should have attained (independent level) in order to fully comprehend the material.

THE FRY READABILITY GRAPH

1. Randomly select three sample passages and count out exactly 100 words in each, starting with the beginning of a sentence. Include proper nouns, initializations and numerals.

2. Count the number of sentences in each passage of one hundred words, estimating length of the last sentence as a fraction to the nearest tenth.

3. Count the total number of syllables in each 100-word passage. If you don't have a hand counter available, simply put a mark above every syllable over one in each word. Then count the number of marks and add 100. A calculator can also be used as a counter by pushing the number "1" and the " + " sign for each word or syllable when counting.

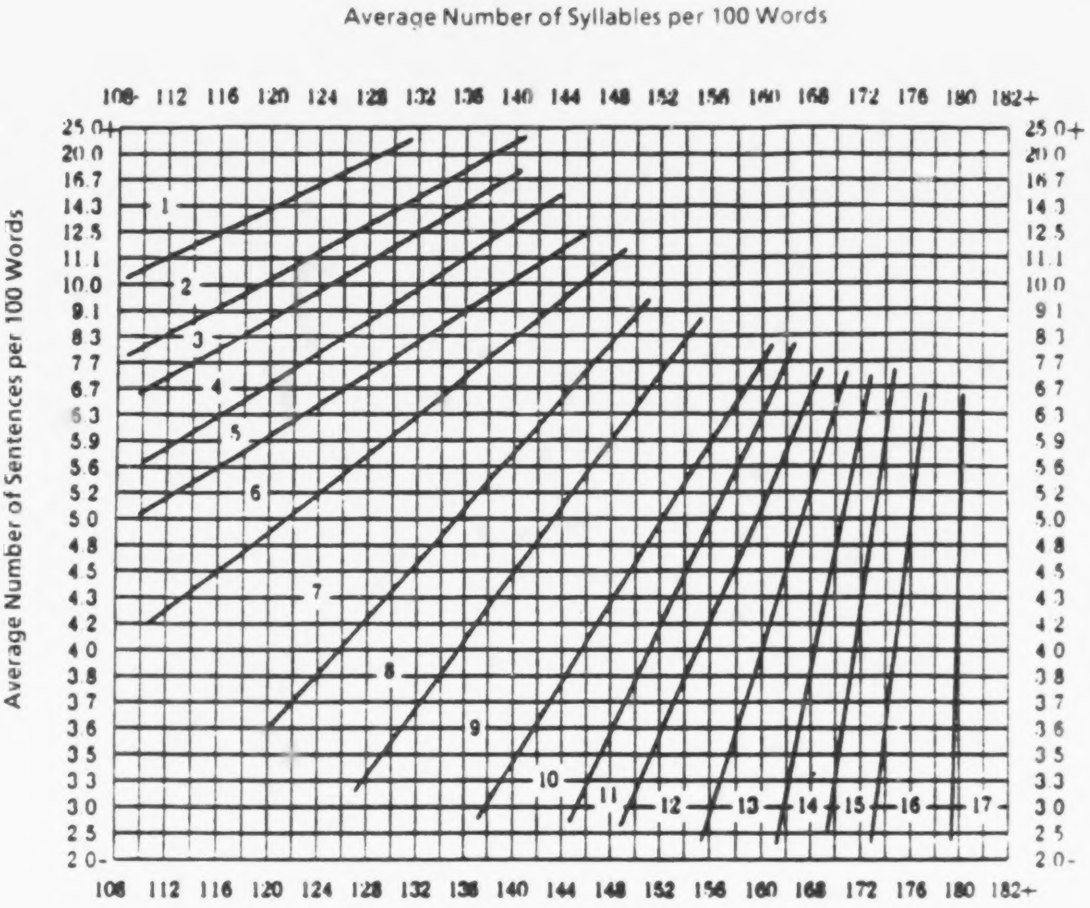
4. Determine the average number of sentences and average number of syllables per 100 words. Plot a point where the two lines intersect on the readability graph provided on the next page. The area where the dot is plotted represents the approximate grade level.

5. If a great deal of variability is found in the syllable count or the sentence count, it may be desirable to put more samples into the average.

6. A word is defined as a group of symbols with a space on either side; thus, Joe, IRA, 1945, and & are each one word.

7. A syllable is defined as a phonetic syllable. Generally, there are as many syllables as vowel sounds. For example, stopped is one syllable and wanted is two syllables. When counting syllables for numerals and initializations, count one syllable for each symbol. For example, 1945 is four syllables, IRA is three syllables, and & is one syllable.

THE FRY READABILITY GRAPH



RESOURCE 2: ASSESSING THE READABILITY OF SCIENCE MATERIALS (cont'd)

USING A CLOZE PROCEDURE

The **cloze procedure** was developed by Wilson Taylor (1963)[1] as a tool for testing reading comprehension. In a modified form, the procedure may be suitably used in science to:

- measure readability
- test for comprehension
- diagnose individual reader's abilities or deficiencies.

PROCEDURE FOR DEVELOPING AND ADMINISTERING A MODIFIED CLOZE

1. Choose a reading passage of approximately 350 words. The passage should be one that students have **not** previously read.

2. Leave the first two sentences intact and delete every **seventh** word thereafter (**A, an** and **the** are not to be deleted. Instead delete the next word.) Leave the last sentence intact.

3. Retype the selection replacing the deleted word with a blank of standard length (12 letter spaces).

4. Have the students read the passage and fill in the blanks. This activity should not be timed.

5. Count the number of correct responses. The wording must match the original **exactly**. Spelling, however, does not count.

6. Calculate the percentage of correct responses.

7. Use the following **guidelines** to estimate students' ability to read **narrative-style** material effectively. (These scores are not to be treated as rigid cutoff points).

   60-100 percent: independent level – the student can read without help
   45-60 percent: instructional level – the student can read with help
   0-45 percent: frustration level – unsuitable for reading

8. Use these **guidelines** to estimate students' ability to read **expository**-style material (e.g., material containing explanations of concepts).
   55-100 percent: independent level
   40-55 percent: instructional level
   0-40 percent: frustration level

---

[1] Taylor, W.L. "Cloze Procedure: A New Test for Measuring Readability". Journalism Quarterly, 30, Fall, 1963, pp. 415-433.

RESOURCE 2: ASSESSING THE READABILITY OF SCIENCE MATERIALS (cont'd)

ALTERNATIVE TECHNIQUES FOR USING THE CLOZE PROCEDURE

1. The Maze Technique (Feely, 1975)[2]

Offer a multiple choice format for each blank. Three alternatives are provided for each blank in random order: 1) the correct word; 2) an incorrect word of the same grammatical class (e.g., verb, noun, preposition); and 3) an incorrect word of a different grammatical class. The maze is more difficult to prepare, but it is less threatening and easier for students to complete than the cloze procedure previously described.

e.g., Many ______ (numbers, varieties, sleek) of wild cats are found on the continents of Africa and Asia including lions, tigers and leopards.
(answer – varieties)

Suggested maze readability cutoff points are:

92-100 percent:	independent level
80-91 percent:	instructional level
75 percent or less	frustration level

2. The Cloze Procedure with a Word List

Prepare a reading passage following the steps previously outlined. Provide a list of the deleted words, in random order, from which students can select the appropriate word for each blank. This alternative may also prove less threatening to students. A sample cloze procedure with a word list follows.

Note: *With all techniques, the key to using the cloze as a tool for developing reading skill is* ***discussion*** *after completion of the exercise. Students should be encouraged to verbalize reasons for selecting a particular word. Immediate reinforcement and feedback regarding the correctness of the students' guesses and the strategies the students used to arrive at their answers will make the cloze an excellent teaching technique in science.*

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[2] Feely, T.M. "How to Match Reading Material to Student Reading Levels: The Cloze and the Maze", Social Studies, 66, 6, November/December, 1975, pp. 249-252.

RESOURCE 2: ASSESSING THE READABILITY OF SCIENCE MATERIALS (cont'd)

A SAMPLE CLOZE PROCEDURE

CAREERS[3]

The transportation technology industry offers a variety of occupational opportunities. Jobs in this field include service station attendants, technical assistants, skilled and semiskilled workers, service and repair personnel, scientists, inventors and engineers.

The amount and type of training ________ with each job. So does the ________ you can expect to earn.

Professional

________, researchers, engineers, teachers and high-level ________ are examples of **professional positions**. College ________ is required for these careers.

Mechanics

Mechanics ________ small engines that are used to ______________________ lawn mowers, garden machines and ________ small machines.

A mechanic must know ________ to use hand tools and measuring ________. A mechanic must be able to _______, to disassemble engines, to examine parts _______ defects and to repair or replace ________ parts.

Skilled Workers

Skilled workers include diesel, ________ and aircraft mechanics. Lengthy on-the-job ________ and/or apprenticeship programs are required.

________ machine operators are classified as **semiskilled** ________. A machine operator requires considerable on-the-job ________.

Little or no training is required ________ **unskilled** workers. Labourers, labour helpers and ________ station attendants fall into this group.

Self-Employment

________ small engine technicians are self-employed. ________ often begin on a part-time ________. They learn about small engines by ____________________ their own engines and those of _______ friends and neighbors. Then they expand their _______ to other customers.

Operating your own business _______ many advantages. You do not have _______ report to anyone else. You ________ set your own hours. You keep ________ the profits. However, owning your own ________ is very hard work. It requires business skills as well as mechanical skills.

WORD LIST

varies
salary
scientists
managers
education
repair
power
other
how
tools
troubleshoot
for
defective
automotive
training
basic
workers
training
for
gas
many
they
basis
servicing
their
business
offers
to
can
all
business

A total of 31 words were omitted from the foregoing selection. Using the guidelines for **expository** style material:

- a score of 18 or better indicates the student is reading at the **independent** level
- a score of 10 to 17 indicates the student is reading at the **instructional** level
- a score of 0-9 indicates the student is reading at the **frustration** level.

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3. For permission to adapt copyrighted material, grateful acknowledgement is made to Glencoe Publishing Company, Los Angeles, U.S. for the excerpts from *General Industrial Education*, by Los Angeles Unified School District, 1988, p. 54.

RESOURCE 3: COMPREHENSION STRATEGIES

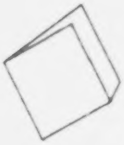
QUESTION-ANSWER-RELATIONSHIP (QAR) STRATEGY

Students may have difficulty comprehending text if they lack strategies for answering questions related to the print material. The **Question-Answer-Relationship Strategy** (Raphael, 1982)[1] assists students to connect the questions to the text or to present knowledge they possess. In addition, QAR is a strategy students may use to locate the information needed to answer questions.

Throughout all three QAR question types, students must first determine the location of the answer. The answers to Type 1 questions are explicit in the passage and may be found by scanning the text. Students must integrate known information with the text to answer Type 2 questions. Type 3 questions provide opportunities for students to make inferences. Practice in using the following three QARs have been shown to significantly improve students' ability to process print information.

WHERE IS THE ANSWER FOUND?

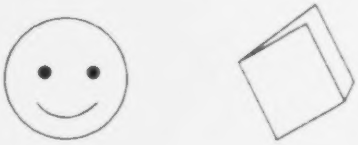
Type 1



Right There

The answer is explicit in the story and therefore easy to find. The words used to make the question, and the words that form the answer are "Right There" in the same sentence.

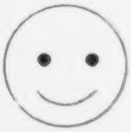
Type 2



Think and Search

The answer is in the story, but is a little more difficult to find. The words in the question and the words in the answer are never in the same sentence. Students would have to "Think and Search" for the answer.

Type 3



On My Own

The answer will not be told by words in the story. Rather, it must be found using background information and/or predictions. Students will think, "I have to answer this question 'On My Own'. The story will not be very helpful."

TEACHING SUGGESTIONS:

1. Introduce the QAR concept and terminology. Use the above figures to discuss the difference between text-based and knowledge-based responses. Stress the differences between the two text-based strategies.

---

[1] Raphael, Taffy E. "Question-Answering Strategies for Children", The Reading Teacher, Nov. 1982, pp. 186-190.

2. Practise the strategies with reading materials using a question from each QAR category. (The specific type of QAR should be identified for the students.) Discuss why the questions and answers represent their respective QARs.
3. Select and distribute reading materials in science with questions. Have students identify the QAR for each question. It is important for students to develop the ability to justify their responses on the basis of the text and individual background knowledge.
4. Continue to practise the strategies with longer selections of written material (600-800 words), from science.

PARAPHRASING (RAP) STRATEGY[2]

DESCRIPTION OF STRATEGY

R – The students **read** the paragraph silently to themselves.

A – After reading the paragraph, the students stop and **ask** themselves what they just read (e.g., Does it make sense? How does it relate to what I already know? How does it relate to what I have already read? What is the main idea the author is trying to get across?).

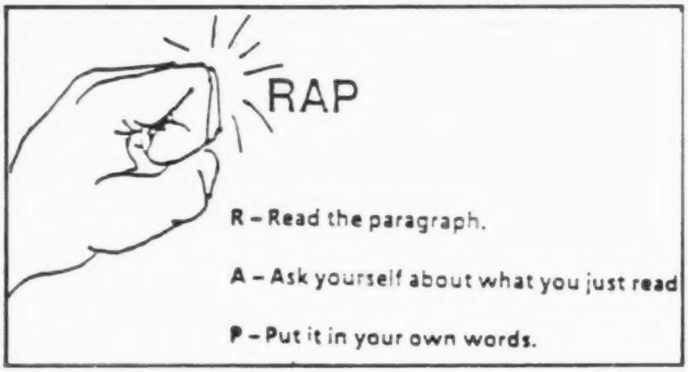
P – Notes are then written based on what has been read and asked, using the student's own words.

SUGGESTED APPLICATION

This strategy can be used to help students remember more of what they read. The strategy is particularly useful for material with much detail, material that is abstract, for note taking and for studying.

TEACHING SUGGESTIONS

Give students an article to read. Ask them to remember what they've read. The next day, give them comprehension questions based on the article. Record their scores. After RAP has been taught, give students an article and ask them to "RAP" it. The comprehension questions are given again the next day. A comparison of scores should illustrate the effectiveness of "RAP" for improving both comprehension and retention.



R – Read the paragraph.

A – Ask yourself about what you just read

P – Put it in your own words.

---

[2] Adapted from *SPELT: A Strategies Programme for Effective Learning/Thinking: Inservice Edition*, SPELT International Ltd., p. 145. Copyright 1987 by R. Mulcahy, K. Marfo, D. Peat, and J. Andrews. Reprinted by permission.

CHAPTER ATTACK (SQ3R) STRATEGY

SQ3R is a study method designed by Robinson (1946)[3], and represents "Survey, Question, Read, Recite, Review". The steps involved in the SQ3R approach are:

1. **Survey.** Notice chapter titles and main headings before you actually read the assignment. Then read introductory and summary paragraphs, and study graphs, charts, etc. This initial survey provides a framework for organizing facts.
2. **Question.** Formulate a list of questions to be answered when reading the passage.
3. **Read.** Read the passage to answer the questions.
4. **Recite.** Try to answer the questions without looking at the material you have read.
5. **Review.** Verify or correct your recited answers by rereading the passage and noting the main points and the relationships that exist among various points.

This method helps students remember content material. SQ3R works well with more competent readers.

SQ3R (Chapter Attack Strategy)

1. Survey – quickly read;
    - a) chapter introduction (BEGINNING)
    - b) chapter summary (END)
    - c) first sentence in each paragraph
    - d) visual aids (pictures, graphs, diagrams)
2. Question – ask a question based on each subtitle
3. Read – read each section to find the answer to your question
4. Recite – write down the answer
5. Review – say or write a summary of what you've learned

---

[3] Robinson, F.P., *Effective Study*, Harper Brothers, New York, 1946.

STRATEGIES FOR USING CONTEXT CLUES

Extracting meaning from context clues involves understanding the redundancy features of language. Students must shift from seeing reading as a process of decoding print to seeing reading as a process of extracting meaning.

Smith (1978)[4] states that redundancy has four components:

- the visual system – what the word looks like
- the semantic system – the meaning of the word
- the syntactic system – the use of grammar
- the orthographic system – the spelling of the word.

All readers need to make use of these four systems to ensure success at extracting meaning from context clues.

Model a strategy for using semantic clues by talking aloud to explain the thinking process. (Explicit teacher explanations are associated with higher awareness of lesson content and greater achievement.)

While instructing students to look for context clues, the teacher may say:

> T: ". . . look for clues in the context. Remember, the context refers to the words before the new word or the words after the new word. Sometimes they are words in a different sentence close to the new word."
>
> The teacher continues to verbalize personal thoughts while using the strategy and emphasizes that a mental process is to be used:
>
> T: ". . . put the clues together with what you already know about that word and decide on the meaning."
>
> Finally, the teacher should emphasize learning the skill and process so that it can be used to read outside of the class:
>
> T: "This is a skill you can use while reading material such as the newspaper, your science book or a library book. Any time you find a word that is new to you, use this skill to determine its meaning."

Supervised practice with a modelled strategy is necessary to ensure its continued use and transferability.

---

[4] Smith, Frank. *Understanding Reading*. Holt, Rinehart and Winston, N.Y., 1978.

RESOURCE 4: DEVELOPING TECHNICAL VOCABULARY

VOCABULARY SELF-COLLECTION STRATEGY

Senior high school increases the demands that are placed upon students to acquire an expanded and refined vocabulary. Developing technical language and gaining understanding of the specialized meanings of common words are examples of these demands.

In order to assist students to develop their vocabulary, instruction should:

- be directed toward vocabulary students need to know - students can often identify these words themselves
- provide students with the skills that are necessary for continued and independent vocabulary growth.

The Vocabulary Self-Collection Strategy (Haggard, 1982)[1] satisfies both of these conditions. Follow these steps:

1. Have each student identify two words they believe the entire class should understand. The teacher will also bring two words. Students are encouraged to choose words they hear or see in their own environment (e.g. words heard on television, in conversation, in a textbook, in a magazine or in the newspaper), thus placing an emphasis on words in context.

2. Ask students write their words on the chalkboard. Each student will identify their own words, where they were found and why the class should understand these words.

3. Reduce the number of words on the chalkboard by eliminating duplications and words that are known by the majority of class members. Keep high frequency words or words judged to be highly important by the majority of the students.

4. Ask individual students to suggest meanings for the words remaining on the chalkboard.

5. Discuss the definitions with the class so as to clarify, refine or extend word meanings. During this process, students should record the words in a personal vocabulary journal, along with their meanings as discussed in class. (Individual students may choose to retain one or more words which were eliminated from the original list.)

6. Use the new words in a variety of ways to provide practice (e.g., make or solve crossword puzzles, write sentences and dialogues).

7. Test student retention of vocabulary at the end of the week. Repeat the cycle as necessary.

One value of this strategy is that it helps to identify words that may be problematic for students. Often, the words identified by students do not coincide with those a teacher or textbook author would isolate as being difficult.

---

1. Haggard, Martha. "The Vocabulary Self-Collection Strategy: An active approach to word learning", Journal of Reading, December 1982, pp. 203-207.

TEACHER INTERACTION TECHNIQUE

The teacher interaction technique (Eeds and Cockrum, 1985)[2] is designed to connect a new word to existing schema in each student's repertoire of vocabulary knowledge. This technique of word meaning instruction helps learners fit new words into an already existing conceptual framework through the following sequence of steps:

1. Prior to beginning a reading assignment, identify the difficult words in the reading selection and choose the words that may become internalized using this strategy (e.g., words lacking in contextual support from which students can determine meanings on their own).

2. Organize a situation where a conceptual network common to most students will be activated (e.g., a situation for the word "peculiar" may be presented as follows: "Have you ever had an experience that made you sit back and say that it was one of the strangest experiences you have ever had? Tell me about it". Listen to several examples of strange happenings and label them "peculiar").

3. Have students write about an event they have heard of or experienced which they personally found very peculiar.

4. Encourage students to write about something that is *not* peculiar (a non-example).

5. Ask students to define "peculiar" in their own words.

   These five steps -- identifying difficult words, activating common experiences, connecting the new word to individual experience, contrasting with a non-example, and translating the meaning into personal language, appear to positively influence the acquisition of new vocabulary.

Research indicates that students using this strategy outperformed other students who were given the same vocabulary items to learn using the dictionary to gain meaning or who were left to gain meaning incidentally by reading for context clues.

---

[2] Eeds, Maryann and Ward A. Cockrum. "Teaching Word Meanings by Expanding Schemata vs Dictionary Work vs Reading in Context", Journal of Reading, March, 1985, pp. 492-497.

VOCABULARY SORTING

The steps that follow suggest a strategy for developing an understanding of technical vocabulary through the use of "word sorting" activities:

- Give students a list of vocabulary items and ask them to categorize the words. Alternatively, ask students to generate their own list of technical or specialized vocabulary from a science topic studied.

- Give category headings, or ask students to decide on their own headings. Indicate to students that more than one classification scheme is possible and that any tabulation scheme which they can justify is acceptable.

- Record any questions that arise during the categorization process.

- If vocabulary items are new to students (i.e., this would be a pre-reading activity), it is best to present the words in context. Students should scan the text, list the new words and then use this as a basis for the vocabulary sorting exercise.

EXAMPLES OF VOCABULARY SORTING ACTIVITIES

The following vocabulary items are commonly used in the study of technologies related to the automobile.

1.	points	plugs	tune-up	condenser	motor
2.	cables	battery	terminals	acid	plates
3.	steering	ball joints	tie rod	front suspension	seals
4.	fender	trunk	hood	grill	body
5.	lubrication	grease	oil	filter	drain
6.	accessories	air conditioning	AM-FM	defogger	clock
7.	tire	hubcap	jack	flat	wrench
8.	gauges	odometer	alternator	temperature	fuel
9.	bench	bucket	seat	front	rear
10.	coolant	thermostat	drain	radiator	cooling system

1. Have students circle the **"Main Idea"** word in each of the ten groupings above.

2. Extract the **"Main Idea"** words from the groupings above and present them as category heading. Scramble the rest of the vocabulary items and have students sort them under the headings.

3. Scramble all of the vocabulary items, and have students attempt to identify both the "Main Idea" words (i.e., category headings) and the "sub-topic" words.

MAKING A CROSSWORD PUZZLE OR A WORD FIND

Step 1: Identify a given list of words or make a list of words that pertain to a particular topic.

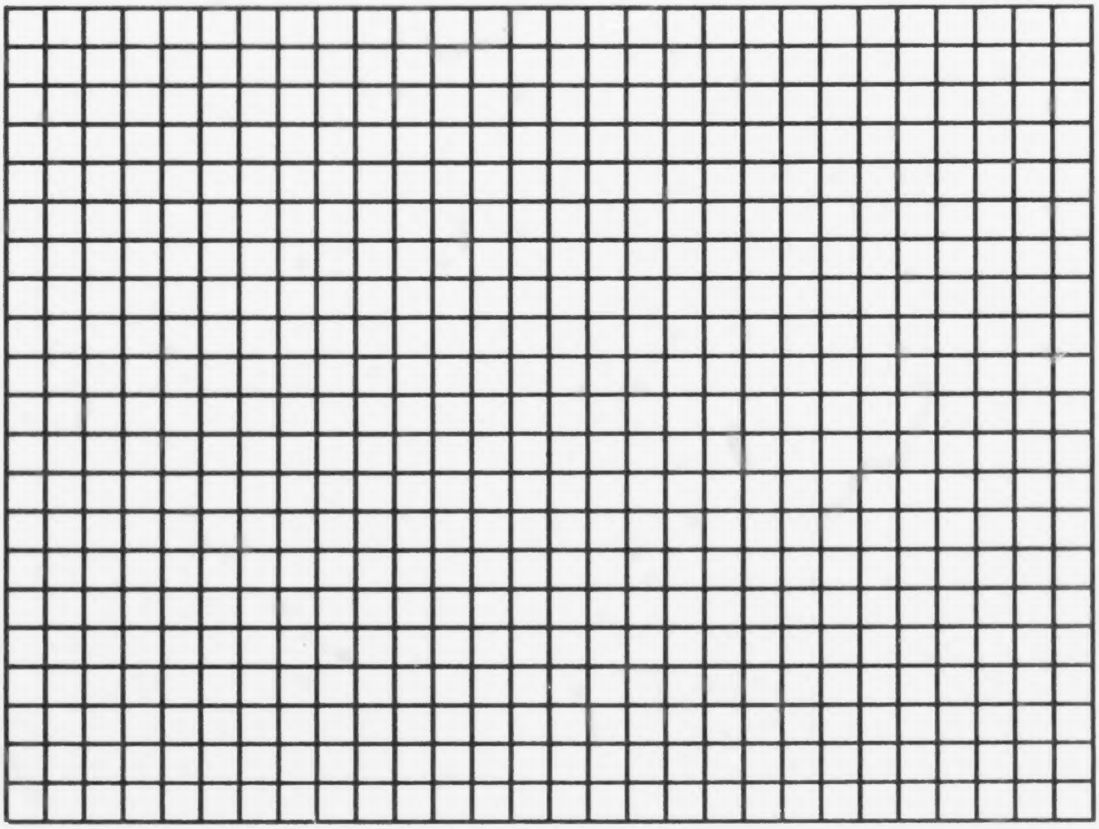
Step 2: Write the words on the grid, interlocking letters as often as possible, going across and down the page.

Step 3: Lay another sheet of paper over the grid and trace only those squares that contain letters. Or, with a felt tip marker, shade unused squares to form dark background.

Step 4: Number the first square of each word in the upper left corner.

Step 5: Number the "clues" or definitions in the same order as the words are numbered on the grid and place clues at the bottom or on a separate sheet of paper.

Crossword Puzzle Grid



Word Identification Strategy (WIS)[3]

Description of Strategy

To be used as a word attack strategy when you don't know how to read a word.

Step 1 – Look at the word in the sentence. Can I guess what it is by reading the words around it?

Step 2 – Look for a prefix. Look at the beginning of the word. Say it.

Step 3 – Look for a suffix. Look at the end of the word. Say it.

Step 4 – Locate the stem. Look at what's left after locating the prefix and the suffix.

Step 5 – Attack the stem. You do this by:

a) Using the rule of 2's and 3's. If the stem starts with a vowel, say it with 2 letters; if with a consonant, say it with 3 letters.

b) Two vowels together sound like one – try both sounds.

Step 6 – Look in a dictionary, Or

Step 7 – Ask someone.

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[3] Adapted from *SPELT: A Strategies Programme for Effective Learning and Thinking Inservice Edition*, SPELT International Ltd. Copyright 1987 by R. Mulcahy, K. Marfo and D. Peat and J. Andrews. Reprinted by permission.

RESOURCE 5: USING ADVANCE ORGANIZERS/CONCEPTUAL

SEMANTIC WEBS AND MAPS

A semantic web or map is a graphic display of the relationship between major and minor ideas. A basic web consists of a core question and a network of strands which, when taken together, display the relationship of the whole to the parts and the parts to the whole.

Semantic webbing activities will:

- assist students to process new information they read by providing a graphic organizer
- help to structure discussion
- assist students to organize and integrate information.

The teacher may also use webbing as a diagnostic tool. It is useful in determining:

- the information students derive from material they read
- the students' understanding of categories and relationships.

The semantic webbing strategy can be used as:

- a pre–reading activity:
  - students can brainstorm and make predictions about the reading
  - an advance organizer to introduce new/difficult vocabulary. The web or map may be constructed on the chalkboard and partially completed prior to the activity

- an activity during reading:
  - the teacher partially constructs a descriptive/narrative/expository web and distributes this to the students. The students complete the web as they read, verifying from the text from the text reasons for their selections from the text. As they locate explicit and implicit text clues, they write these in the boxed nodes or strands

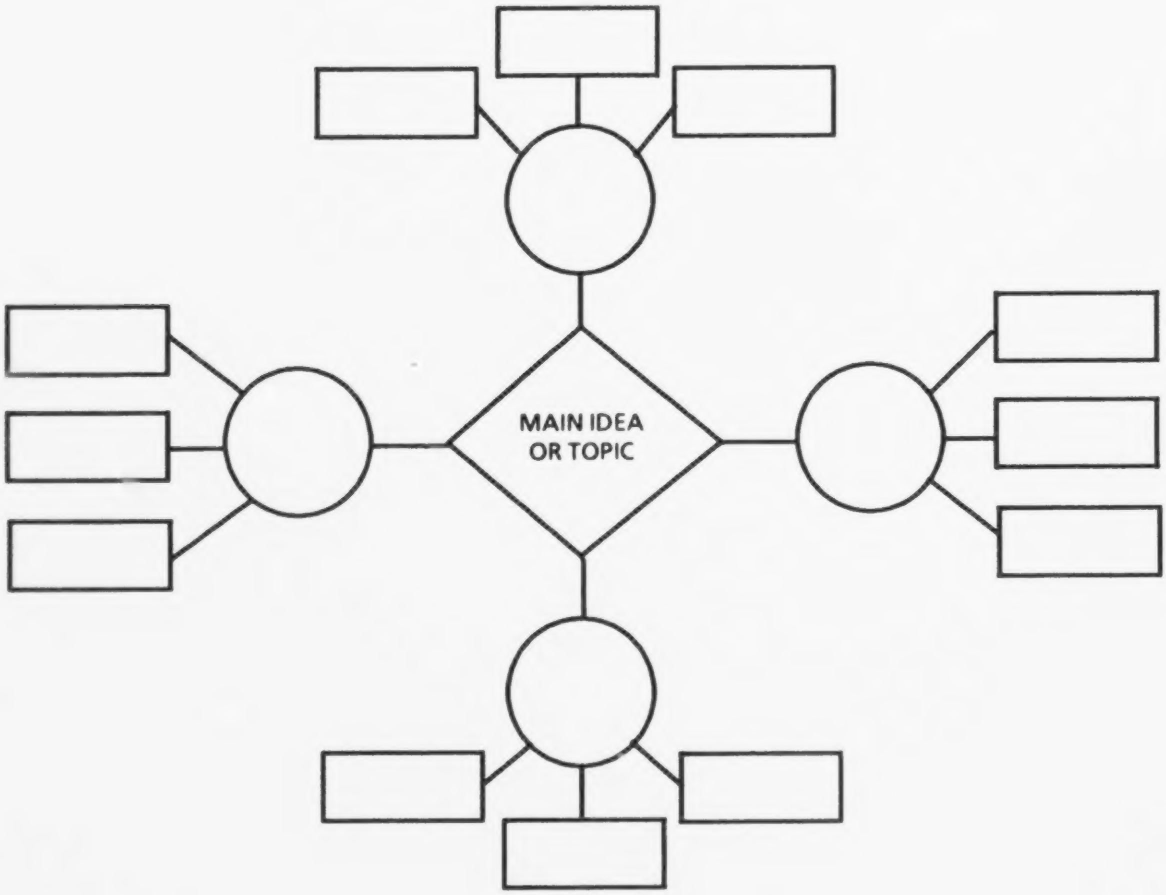
- an activity after reading:
  - students can modify/correct a pre-reading web to verify and extend their knowledge

- a pre–writing planning activity:
  - students may use a semantic web to organize ideas used in a writing assignment

The purpose of the activity will determine when and how semantic webbing strategies are used. The pages that follow provide examples of:

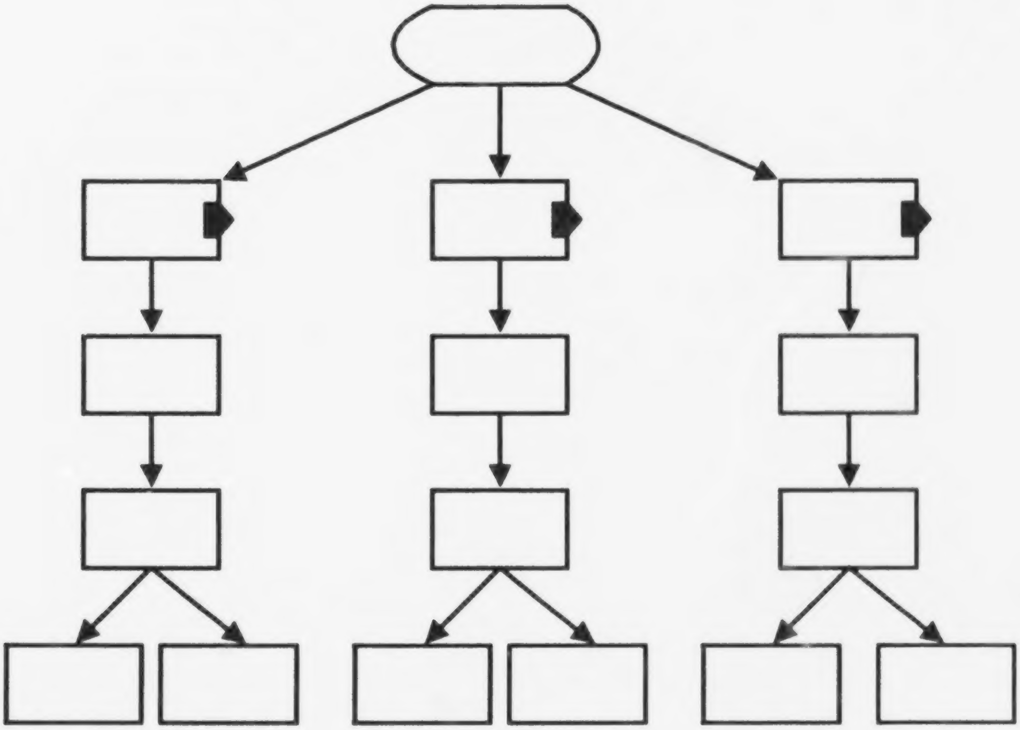
- a descriptive or thematic web
- a narrative sequential map
- a comparative and contrastive web.

A DESCRIPTIVE OR THEMATIC WEB


MAIN IDEA
OR TOPIC

A NARRATIVE SEQUENTIAL MAP

(time order)



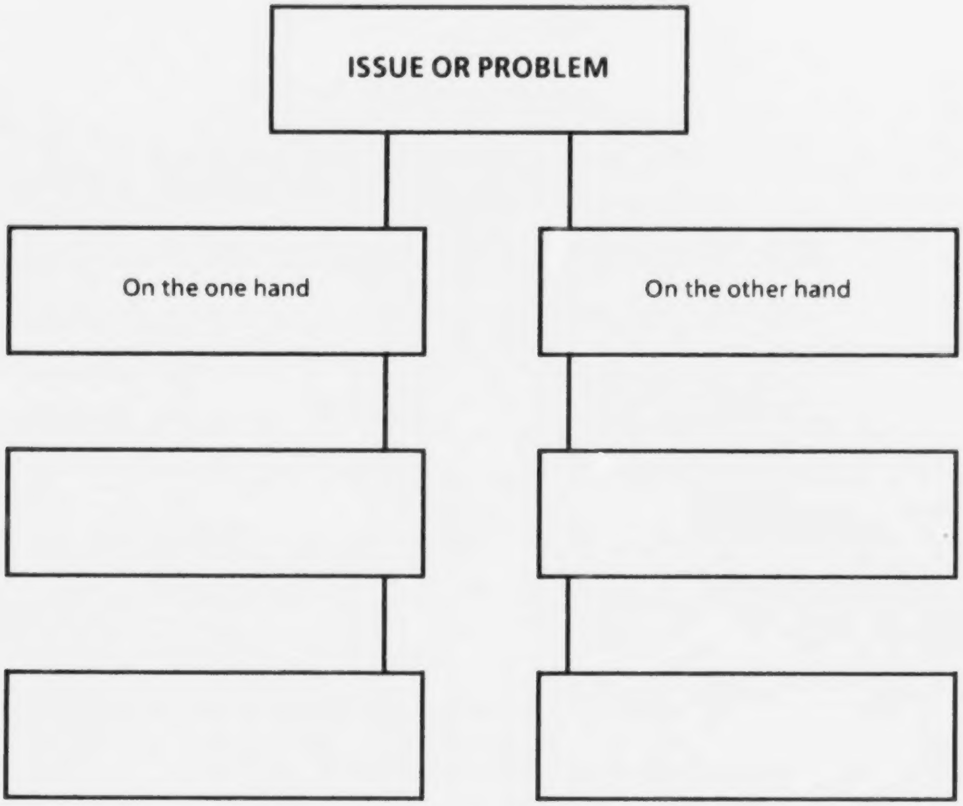
This "map" configuration can be used to visually display:

- the steps in following instructions (e.g., following directions for an experiment)
- the chronological order of a sequence of events (e.g., explaining the operation of a technological device).

Teachers may wish to revise this web according to the difficulty of the activity or complexity of the sequence of events (e.g., the bottom six figures may be removed).

RESOURCE 5: USING ADVANCE ORGANIZERS/CONCEPTUAL OVERVIEWS (cont'd)

A COMPARATIVE AND CONTRASTIVE WEB


ISSUE OR PROBLEM
On the one hand
On the other hand

CONCEPT CIRCLES[1]

Students can be encouraged to organize and identify relationships among concepts they study through the use of concept circles. The steps that follow represent a strategy for drawing concept circles:

1. Let a circle represent any science concept.
2. Print the name of that concept (e.g., plant, temperature) inside the circle.
3. When you want to show that one concept is included within another concept (e.g., all birds are vertebrates), draw a smaller circle within a larger circle. Label the smaller circle by printing the name of the narrower, more specific concept within it. Label the larger circle by printing the name of the broader, more general concept within it.
4. When you want to show that some instances of one concept are part of another concept (e.g., water contains minerals), draw partially overlapping circles. If you want to show that one of the concepts is more inclusive (e.g., broader) than the other, use a larger circle for that one. Label each circle.
5. When you want to show that two concepts are not related (e.g., no crustacean is a vertebrate), draw separate circles and label each one.
6. You may use up to five concept circles in your diagram. They can be separate, overlapping, included, or superimposed. Label each one.
7. The relative sizes of the circles in your diagram can show the level of specificity for each concept. Bigger circles can be used for more general concepts.
8. Coloured pens, markers, pencils or highlighters may be used to colour your concept circle diagram in order to make the relationships between concepts easier to visualize, understand and recall.
9. When the concept circle is finished, a title describing it should be written in the upper left-hand corner of the page and a sentence that summarizes what the diagram shows should be written in the area directly beneath the diagram.

Sample concept circles are provided on the following page.

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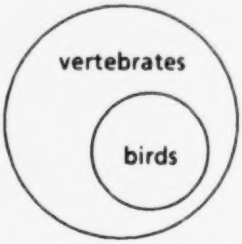
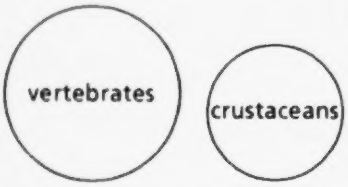
[1] From *Drawing Concept Circles: A New Way to Teach and Test Students*, by James H. Wandersee. Copyright 1987 by James H. Wandersee. Adapted by permission of the author.

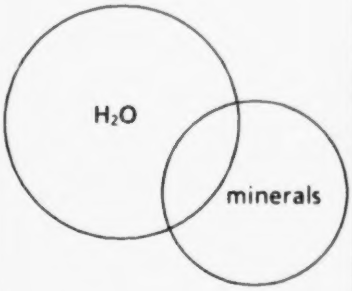
SAMPLE CONCEPT CIRCLES


vertebrates
birds

One concept is included within another concept.

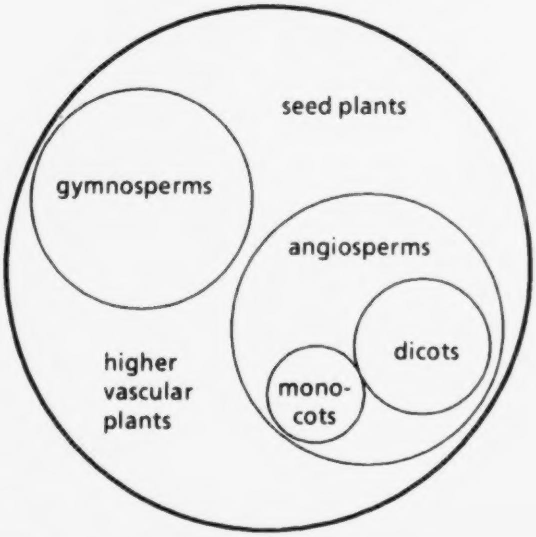

vertebrates
crustaceans

Two concepts that are not related.


H_2O
minerals

One concept is part of another concept in some, but not all instances.

The Classification of Seed Plants


seed plants
gymnosperms
angiosperms
dicots
mono-
cots
higher
vascular
plants

RESOURCE 6: MAKING SUMMARIES

USING OUTLINES AND IDEA DIAGRAMS

Outlines similar to the one illustrated below may aid students in organizing their thoughts during the pre-writing phase of a writing assignment or in summarizing material that has been studied.

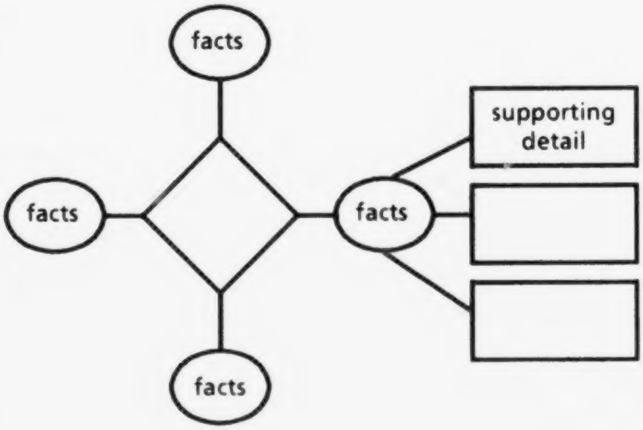
Title

I. Main Idea ____________________
  A. fact/supporting detail____________________
  B. fact____________________

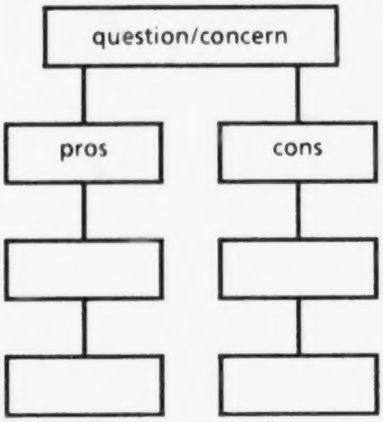
II. ____________________
  A. ____________________
  B. ____________________

Idea diagrams (e.g., semantic webs/maps, comparative/contrastive maps) can also be used in summarizing and pre-writing activities. Two simple configurations are offered as examples.

SEMANTIC WEB/DESCRIPTIVE MAP


facts
facts
facts
supporting detail
facts

COMPARATIVE AND CONTRASTIVE MAP


question/concern
pros
cons

EVALUATION GUIDE FOR SUMMARIZING[1]

Your summary will be marked on the basis of three criteria:

- identification of the main topic
- identification of other details that are relevant, and
- classification of the details to the main ideas and in relation to each other.

Your assignment will be scored out of 20 marks. The scale at the bottom of the page will help you interpret your score.

	Possible Score	My Score
1. Did you correctly identify the main topic? Did you present it clearly and briefly?	5	
2. Did you include all the important subheadings? Are they of equal importance?	5	
3. Did you relate other relevant information to each appropriate subheading? Have you omitted any important information? Have you included any unimportant information?	5	
4. Did you use an appropriate semantic web or skeletal outline?	3	
5. Is the overall organization of your notes easy to follow and understand?	2	
TOTAL	20	

Scale Point

One	The summary is incomplete. It fails to include most relevant information. The summary scores zero to five points.
Two	There are serious omissions of subheadings or there is a failure to include information below the subheadings. Information may be presented at an inappropriate level. The summary scores six to 10 points.
Three	Generally, main topic and most subheadings are present but there may be several omissions of relevant details. There may be some inconsistencies. The summary scores 11 to 15 points.
Four	The main topic is correctly identified. No more than one major subheading is omitted. Most relevant information is included. The summary scores 16 to 20 points.

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[1] From the *Junior Secondary Science Curriculum Guide and Resource Book* by the British Columbia Ministry of Education. Copyright 1983 by the British Columbia Ministry of Education. Reprinted by permission.

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RESOURCE 7: USING CRITICAL THINKING SKILLS

de BONO'S TOOLS FOR TEACHING THINKING[1]

> "Thinking is a skill, and like a skill, it can be developed and improved if one knows how."
>
> – Edward de Bono

There are many proponents of direct teaching of thinking as a skill and Edward de Bono is among the internationally recognized authorities in the field. He proposes a "tools method" whereby techniques for guiding the thinking processes are taught as discrete skills, practised in elementary contexts and later applied spontaneously and independently to real problems. The real life problems may change, but the tools to solve those problems remain applicable. A list of thinking tools follows.

PMI Tool This tool reminds the thinker to first direct attention to the **Plus** points, then to the **Minus** points and finally to the **Interesting** points of a new idea. The thinker is encouraged to make an honest and thorough search in each direction to complete the thinking process relative to the problem.

Example:
What would happen if the two holiday months were July and January?

Plus	Minus	Interesting
• winter ski holiday	• indoors during warm months	• new types of family holidays
• increase in types of winter recreation	• more travel during potentially dangerous winter months	• studying, concentrating on school during August

A PMI can be used to clarify and assess alternatives in a variety of everyday situations.

e.g.,
- Should I complete my homework or go to the hockey game?
- Should I attend the dance when my parents would be unhappy with my decision?
- Should I lend a friend my new sweater?

C and S (Consequences and Sequels):

- listing the immediate, short term and long term effects of a choice to help make a decision.

Immediate Consequence	Short Term Consequence	Long Term Consequence

CAF (Consider All Factors):

- brainstorming and listing everything that needs to be considered in thinking about a problem, formulating a plan, organizing the input and making a decision.

CAF

FIP (First Important Priorities)

- making and examining a list and prioritizing items in the list.

FIP

AGO (Aims, Goals, Objectives)

- developing an action plan and/or making a decision by examining the desired outcomes.

AGO

RESOURCE 7: USING CRITICAL THINKING SKILLS (cont'd)

APC (Alternatives, Possibilities, Choices)

- searching for alternatives and extending beyond the obvious in order to consider other possibilities and choices.

APC

OPV (Other People's View)

- collecting, examining and considering the views of others.

OPV

Teachers are encouraged to:

- provide opportunities for students to practise using these tools in meaningful and novel problem-solving contexts
- discuss with students which tools would be most appropriate in particular problem situations.

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1. de Bono, Edward. "The Practical Teaching of Thinking Using the CoRT Method", Special Services in the School, Vol. 3 No. 1/2, Fall/Winter 1986, pp. 33-47.

RESOURCE 7: USING CRITICAL THINKING SKILLS (cont'd)

A CRITICAL THINKING WORKSHEET

Choose a topic/issue that you would like to critically examine. Following the steps of critical thinking outlined below, examine the topic/issue and record the results of your analysis.

SOME STEPS FOR CRITICAL THINKING

1. Choose a topic/issue to examine: ______________________________

____

2. Ask questions about the topic/issue:

(a) What are the positive characteristics of this topic/issue? ____________

____

____

(b) What are the negative characteristics? ______________________

____

____

3. Gather additional information as required. ______________________

____

____

4. Review the information. Are there more positive characteristics than negative? More negative characteristics than positive? ______________________

____

____

5. How will you react to this issue? ______________________________

____

____

RESOURCE 8: GIVING AND FOLLOWING DIRECTIONS

Directions vary in terms of their level of difficulty. The directions outlined below have been categorized according to their level of difficulty.

EASY

- following sewing patterns
- taking medicine
- following traffic directives
- preparing packaged foods (e.g., TV dinners, macaroni dinners)
- heeding warning signals on equipment (e.g., oil light in car)

MEDIUM

- following recipes
- building a model
- following laundering instructions
- operating common household appliances (e.g., oven timer, vacuum cleaner)
- following rules for board games (e.g., Monopoly, Clue)
- maintaining and using sports equipment (e.g., bikes)
- operating equipment from a rental shop (e.g., carpet cleaner)
- using household chemicals and cleaners (e.g., oven cleaner, drain cleaner)

DIFFICULT

- assembling furniture
- operating electronic equipment (e.g., VCR, stereo)
- filling out government forms
- maintaining major home appliances/equipment (e.g., furnace)

ACTIVITIES

1. Ask students to identify directions that they must follow in science class. Categorize these directions as easy, medium or difficult.

2. Ask students to identify the components of good directions and strategies that will help them to give and to follow directions in an appropriate manner..

3. Provide opportunities for students to describe the safety risks involved in giving poor instructions or not following instructions precisely in laboratory situations.

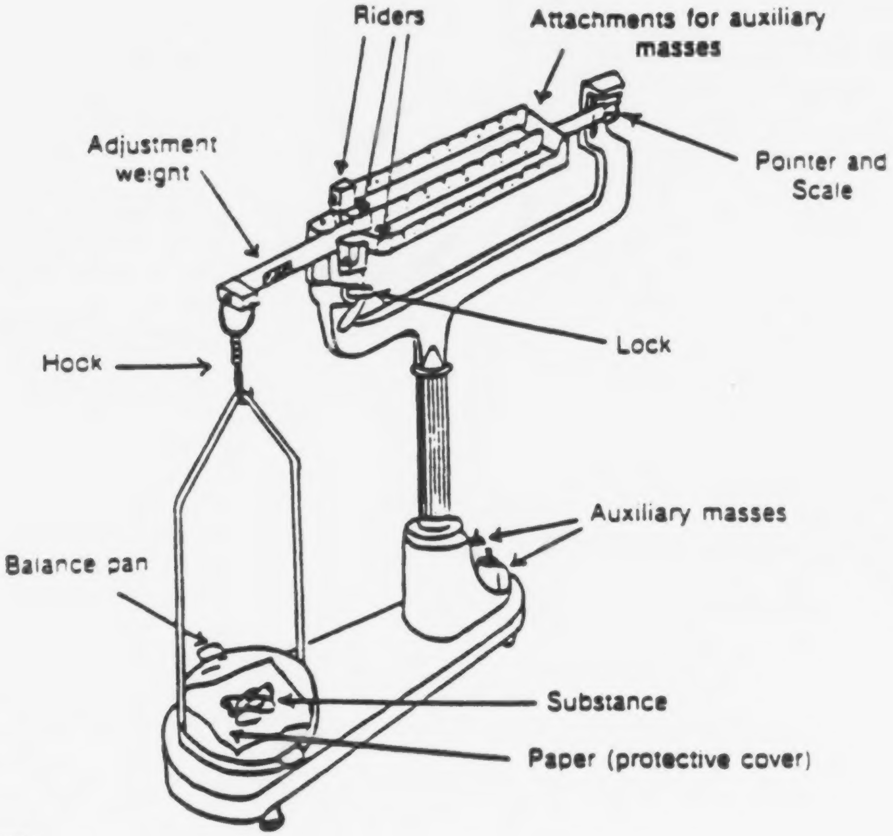
4. Identify self-monitoring strategies that can be used when giving directions to someone else. (e.g., asking the receiver questions in order to determine if directions are understood.)

5. Invite appropriate community members to attend a class and explain directions that they follow in performing routine tasks at home or at work. These tasks might relate to:
   - changing oil in a vehicle
   - repairing a mechanical/electrical device
   - using a special-purpose tool
   - caring for a pet
   - using a chemical product.

WRITING DIRECTIONS[1]

SITUATION

Imagine that it is September 1st, and you have just arrived in science class. Your new lab partner has never been able to use a triple beam balance correctly and is always asking you to do it. You are fed up with doing all the lab work, so you decide to write an excellent set of directions on how to properly determine the mass of an object using a triple beam balance.


Riders
Attachments for auxiliary masses
Adjustment weight
Pointer and Scale
Lock
Hook
Auxiliary masses
Balance pan
Substance
Paper (protective cover)

ASSIGNMENT

Write a clear set of directions for your partner. If you ask, your teacher will provide you with a balance. When you have written the directions, examine the evaluation guide provided and revise your directions.

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[1] From the *Junior Secondary Science Curriculum Guide and Resource Book* by the British Columbia Ministry of Education. Copyright 1983 by the British Columbia Ministry of Education. Reprinted by permission.

AN EVALUATION GUIDE FOR WRITING DIRECTIONS[2]

The marking criteria listed below will be used to measure your ability to write directions for laboratory procedures. Score your assignment to the maximum number shown on the right of each statement.

	Possible Score	My Score
1. The **title** is present and gives an indication of the purpose of the directions. An example might be, "How to Fly a Kite".	2	
2. **Supplies** and **equipment** are all identified and correctly classified.	2	
3. The **instructions** are listed:		
• in complete sentences	3	
• in the correct sequence	4	
• without any omissions	4	
• in a numbered order	2	
• using present tense	2	
• without addressing 'you'.	1	
4. **Safety hazards**, if they exist, are identified and noted in the appropriate location.	2	
5. The **overall organization** is easy to follow.	*3 or 5	
Total	25	

* Score 3 if identification of safety hazards is necessary and 5 if it is not.

Scale Point

One	The directions are incomplete and/or in an inappropriate format. The directions obtain zero to 10 points.
Two	There are serious problems with format and there may be omissions. The directions obtain 11 to 15 points.
Three	The instructions are logical although there may be some weaknesses in format. The directions obtain 16 to 19 points.
Four	A clear set of directions is presented in a standard format. The directions obtain 20 to 25 points.

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RESOURCE 9: STRATEGIES FOR DISCUSSING AND DEBATING

PREPARING FOR GROUP DISCUSSION

Many science activities centre around discussion groups and provide opportunities for verbal communication among students. Students may lack experience in the give-and-take of discussion groups. Some direct teaching of discussion skills may prove useful.

SETTING RULES

Members of the discussion group may increase their involvement if they feel they have some ownership of the rules. Have student generate discussion rules and post these as reminders. Rules may change according to the goals of the group, but ensure that everyone understands the rules.

GROUP SIZE AND SEATING ARRANGEMENTS

Groups of five are ideally suited to discussion. A circle formation permits all members to participate equally.

DECISION MAKING

Reinforce the process by which decisions will be made: consensus, majority vote, compromise, expert or authority in the group. The strongest decisions are those arrived at by group consensus, yet consensus is often difficult to achieve.

MEMBERS' ROLES

Students may require assistance in determining their roles and functions in the group (e.g., a recorder takes notes, a chairperson keeps the topic on track and encourages all members to get involved). The natural leader of the group may need assistance to avoid replacing the "appointed leader".

GROUP GOALS

Remind students of the specific goal of the group discussion and teach them strategies for keeping the discussion directed at reaching the goal (e.g., calling attention to and recording major ideas).

GROUP PROCESS SKILLS

Students may require assistance in developing the following group process skills:

- asking probing questions
- intervening when a member becomes disruptive
- calling attention to major ideas
- keeping time
- remaining on topic
- asking for opinions, information and suggestions from others
- offering opinions, information and suggestions
- correcting others
- asking for clarification
- releasing tension in the group.

RESOURCE 9: STRATEGIES FOR DISCUSSING AND DEBATING (cont'd)

CHECKLIST FOR SELF-EVALUATION IN GROUP DISCUSSIONS

The following checklist can be used to evaluate personal participation in group discussions. Take a few minutes to reflect honestly on your contribution to the class. Put a check (✓) next to those statements that are true of you in today's discussion and fill in the blank spaces appropriately.

1. ___ I contributed ideas without waiting to be asked.
One idea I contributed was ____
____.

2. ___ I kept my remarks on topic.

3. ___ I supported my ideas and remarks with specific details (e.g., I gave an example).

4. ___ I listened carefully and thoughtfully.

5. ___ I can recall other group members' ideas.
One important idea was ____
____.

6. ___ I encouraged other group members to tell more about their ideas.

7. ___ I asked other group members questions about their ideas.

8. ___ I respected other members ideas and opinions even if I disagreed.

9. ___ I let other members finish speaking without interrupting.

10. ___ I changed my mind abut something as a result of listening to other members' opinions.
I changed my mind about ____
____.

11. ___ I think I might have made someone else change their mind about something as a result of an idea I contributed.
The issue was ____
____.

12. ___ I have a clearer picture of my own concerns/problems as a result of this group discussion.

13. ___ I have a better understanding of other people's concerns/problems as a result of this group discussion.

14. ___ Here is something I learned from today's discussion: ______________________________

FORMAL AND INFORMAL DEBATES

Debating is a good technique to use to get students to think through complex issues carefully. While debates can take many forms, the following procedures have proven particularly effective in the classroom.

INFORMAL DEBATE

The class will form two teams – one in support of and one against the debate statement. The teams should be seated facing one another.

Arguments are presented by a team member from one side, then a team member from the other side. Arguments are presented alternately until all students have had an opportunity to speak. Each speaker will be allowed one minute. (A person should be selected to be timekeeper.)

This debate should be a spontaneous activity. Teams should not prepare in advance but try to develop the arguments as the debate progresses. Each student will need to listen carefully to the arguments that are presented and introduce his or her own new idea. The object is to try to think and organize ideas quickly. It is almost like brainstorming where someone presents an idea and that idea leads to another idea. Each debater can build his or her idea from the previous idea or present a totally different idea.

After all arguments have been presented, the class will then discuss some of the main points that were brought out by each side. What were the best arguments presented by each team?

FORMAL DEBATE

Organization

Judges

A minimum of three members of the class should serve as judges (or preferably, invite three persons from outside the class). One of the judges must serve as timekeeper and monitor the length of each of the presentations. A second judge should act as the Presiding Judge and supervise the proceedings. He or she will be responsible for keeping the debate orderly and calling on the presenters in turn.

Teams

After the judges have been selected, the remainder of the class should form two equal teams -- one supporting the debate statement and the other opposing the statement. Each team should elect a coordinator whose responsibility will be to organize the team members. The recorder will take notes on the group's activities and decisions. The recorder and coordinator may be the same person, depending on the size of the task.

Preparing for the Debate

Team members will meet to develop the arguments for their position. Each team will first make a list of the major arguments (abbreviated statements) supporting its position. The coordinator will review the list to make sure that all the important arguments have been included and no argument is duplicated. There should be as many arguments as there are team members. If there are too many, the least important should be eliminated. If there are too few, additional ones should be developed.

Make two copies of your team's list and exchange one copy for the list from the other team.

Each team member will select an argument from his or her own list to develop into a short, two- to three-minute defence. He or she will also select an argument from the list submitted by the other team and prepare a two- to three-minute rebuttal (counterargument). Each person will thus be responsible for two arguments: one that supports his or her team's position and the other that answers/attacks the other team's position.

The Debate

The debaters make their presentations in the following order:
3 min. – Team 1 presents argument
3 min. – Team 2 presents rebuttal
3 min. – Team 2 presents argument
3 min. – Team 1 presents rebuttal.

The sequence is repeated until all debaters have presented their arguments and rebuttals. A five-minute summation speech is then given by a member (usually the coordinator) from each team. This summation reiterates the most important points made by the team members.

Judging

A convenient method for judging the debate is to evaluate each set of arguments in turn. After each argument and counter argument is presented, the judges will determine which one of the debaters delivered the most effective and convincing argument. Each judge will set up a score sheet similar to that shown below and assign points as follows:

SCORE SHEET

	Team 1 (Pro)	Team 2 (Con)
Argument 1		
Argument 2		
Argument 3		
Argument 4		
Total Points		

4 points = excellent 3 points = good 2 points = fair 1 point = poor

DEBATING POINTERS

The following tips may be helpful to your students in their preparation for, and presentation of, a debate argument.

- Skillful debating is skillful communication. Make sure your argument is clearly stated and well supported by evidence.
- Explain why your argument is important. This is best conveyed by presenting examples of possible effects.
- Present the argument in a logical sequence, making the most important points first and backing them with sound evidence.
- Speak clearly and slowly so that your argument can be followed by all listeners.
- Be forceful and imaginative. Concentrate on conveying the main issues of your argument.

RESOURCE 10: INFORMAL ESSAY WRITING

WRITING AN INFORMAL ESSAY[1]

SITUATION

Each month we read of the health hazards and environmental damage caused by improper handling of chemicals: the train derailment at Mississauga, Ontario; the spillage of chlorine gas on Main Street in Vancouver; and the use of urea formaldehyde foam as household insulation, are three recent examples.

ASSIGNMENT

Locate a newspaper article that describes the hazards associated with an environmental issue. After considering both sides of the issue, write a letter in which you state your opinion on the matter, the reasons for it, and your recommendations. Your letter should not exceed 250 words. Send your letter to an appropriate government official.

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AN EVALUATION GUIDE FOR INFORMAL ESSAY WRITING[2]

Your assignment will be marked on the basis of two criteria.

- A clear statement of opinion is made.
- Supporting statement. Supply evidence for your opinion by relating an incident, giving an example or explaining relevant information.

Scale Point

One	No opinion is stated. The essay or letter is not on topic.
Two	Opinion is/are offered but with little or no relevant support.
Three	Opinion(s) is/are stated with support, but the essay or letter loses effectiveness because supporting statements are wordy, trite, or overgeneralized.
Four	The opinion(s) is/are stated clearly and concisely. The type of data selected is especially convincing; generally more than three pieces are provided.

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ASSESSMENT/EVALUATION

The goal of science education during the 1980's, as stated by the National Science Teacher's Association, is to develop scientifically literate individuals who understand how science, technology and society influence one another, and who are able to use this knowledge in their everyday decision making. Furthermore, the 1984 Science Council of Canada report, *Science for Every Student*, recommends that:

- science education provide a more accurate view of the practice, uses and limitations of science
- science education include study of how science, technology and society interact
- students be taught how Canadians have contributed to science and how science has affected Canadian society
- teachers and curriculum planners evaluate students' progress in all the goals of science education, not just their learning of scientific content.

These recommendations have formed the foundation for the goals of the Science 16-26 program. Assessment and evaluation practices should provide feedback and evidence of progress toward these instructional goals. A singular assessment technique cannot provide this evidence. Assessment must go beyond determining the percent of correct responses on a test based on scientific facts, and needs to reflect:

- how students approach "doing" science
- interactions among science, technology and society
- applications of science in practical situations.

It is important to recognize that through the process of evaluation we evaluate students' **performances** and not the students themselves. This understanding helps one avoid permanently classifying a student as a good student or a poor student. Performance can and does change, and teachers should be aware of these changes.

Suggestions and ideas for assessing and evaluating students' performance have been included in this section of the manual, and focus attention on the use of:

- Observation
- Interviews
- Inventories/Checklists
- Anecdotal Records
- Individual and Group Projects
- Written Assignments
  - Laboratory Write-Ups and Reports
  - Diagnostic Writing Assignments
  - Paper-and-Pencil Tests.

The evaluation strategies suggested in this manual are not intended to be discrete, and should be used in conjunction with other strategies. For example, a checklist may be used to document desirable problem-solving behaviour in the classroom, and also to guide discussion and evaluate performance in an interview. Furthermore, teachers are encouraged to extend the application of these evaluation strategies to situations beyond those that are discussed.

Additional examples of evaluation strategies are provided in:

- *Evaluation of Student Progress, A Workshop Manual for Administrators and Teachers* (by Science Education Consultants, Alberta Education)
- *Individualized Science Instructional System Teacher Resource Guide* (by Glen Hutton, Globe/Modern Curriculum Press).

OBSERVATION

Although teachers make observations all the time, when observations are documented their effectiveness as an evaluation strategy increases immensely. Documented observations can provide the raw data required for analysis and diagnosis, and establish a basis on which to make remediation or enrichment decisions.

Science lessons usually have a component in which students work on assignments and projects individually or in small groups. At this time teachers can observe students at work, looking for specific behaviours or outcomes, asking questions and making suggestions. Elements of the learning process that might be monitored through observation include:

- understanding of concepts/skills
- method of attacking problems
- work habits
- level of independence with work
- interpersonal skills and social growth.

Documentation of behaviours that are observed may occur in the form of anecdotal records or checklists. Teachers can file anecdotal records and checklists in a student folder where samples of daily work, project reports and other artifacts are also placed.

CLARIFICATION/EXAMPLE

Anecdotal Record

Name	Date	Situation	Behaviour	Comment
Nitan	1/17	investigation of electromagnetism, variables affecting strength of the electromagnet	quick to help neighbouring students	understands basic concepts of electromagnetism
	1/25	researching/reporting local methods of producing electrical energy	unable to organize and communicate information gathered	use more pre-writing activities (e.g., semantic mapping, topical outlines)

A sample checklist that can be used in observing student behaviours is provided as Resource 1: Observational Checklist of Student Behaviours.

Audiotapes or videotapes can also be used to provide records of specific learning outcomes. Photographs are useful in providing a record of project work. In addition to providing the tangible items that parents like to see at conference time, these records of student performance enable the teacher to measure progress with more objectivity than simply through remembering what was done.

INTERVIEWS

A planned interview with a student or group of students is an effective technique for assessing knowledge, understanding, thinking style, attitude or personal interests. An interview removes the restriction of writing, and enables the teacher to delve more deeply into students' thought patterns and how they go about finding an answer or solving a problem. Although written responses on an assignment may indicate areas of concern, more information is often required before appropriate remediation can be provided. Remediation strategies that are based solely upon the analysis of written responses may in fact be inappropriate at times. Holding interviews with students can reveal both surprising strengths and unsuspected weaknesses in their understanding of scientific thought processes.

Some guidelines for conducting interviews are provided below.

- Establish an atmosphere of acceptance. Students must feel comfortable enough to verbalize their ideas freely. By accepting a student's responses without judgment, but with encouragement to elaborate further, you are communicating not only respect for the student's thinking but also a curiosity to learn more. Whether right or wrong, each response has the potential of providing information about the student's level of understanding.

- Ask probing questions. During the interview, ask questions and introduce materials that will cause the student to extend and apply concepts/skills to new areas. Rephrase questions using vocabulary familiar to the student so as to clarify both your intent and the student's thinking. Although some of the questions you ask should be planned, others should be invented spontaneously in order to test your hunches about the student's thinking. Questions asked may take some of the following forms:
  - How did you . . .?
  - Why did you . . .?
  - How do you know that . . .?
  - Tell me more about . . .?
  - What else might happen if . . .?
  - Can you describe . . .?
  - What made you ask that question?
  - How do you feel about . . .?

- Pace the interview appropriately. By allowing an adequate pause following each question before repeating or rephrasing it, you are giving the student time to interpret the question and construct the response. On some tasks, the student may need more than a thirty-second pause, whereas on others, three seconds will suffice. Also, by allowing an adequate pause following the student's response, you are indirectly encouraging him or her to elaborate on his or her initial response.

- Be prepared to coax and encourage the student to make a response. A frequent response given by the student may be "I don't know" or "I forgot". Sometimes an extended pause can coax out productive thinking. At other times, the teacher can encourage a response to questions about which the student is unsure by saying:
  - "I know it's not easy to think about. Just give me your best idea."
  - "Pretend that you did know. How do you think it might be done?"

Interviews should have a definite purpose and both teacher and student should be aware of the purpose. Interviews must be planned in advance. In preparing for an interview, the teacher should consider:

- What questions will I ask?
- What basic understandings will I initially assess?
- How can I incorporate the use of manipulative materials?
- How can I vary the task and questions to obtain different perspectives on the student's ability?

CLARIFICATION/EXAMPLE

A Structured Interview

1. Identifying and Understanding the Problem
    - Can you describe what you were asked to do in this assignment?
2. Selecting and Using Appropriate Strategies
    - What methods did you use to do this assignment?
    - How did you decide which methods to use?
    - Which methods worked the best?
3. Selecting and Using Data
    - What specific information did you obtain by conducting this investigation?
    - How do you intend to use this information?
4. Solving or Answering the Problem
    - What was the outcome of this investigation?
    - What steps did you go through in completing this assignment?
5. Determining the Reasonableness of the Solution
    - How did you decide if the outcome of this investigation/assignment was reasonable?

Maximum benefits can be gained from an interview by reflecting on your interaction after listening to an audiotape playback. Considerable value can also be gained from sharing your tape with a colleague. By discovering how students interpret and view a problem, the teacher will be better able to make effective on-the-spot decisions in the classroom.

Guides for conducting different types of interviews have been provided at the end of this section, and include:

- Resource 2: Gaining Information From Text
- Resource 3: Interview Guide for Inquiry/Problem Solving
- Resource 4: Interview Guide for Project Work.

INVENTORIES/CHECKLISTS

Inventories and checklists are documentation strategies that are used conjunctively with other evaluation strategies. They can be easily designed and customized to meet many different needs and situations. Generally a matrix is created, with indicators of desirable behaviours/outcomes on one side, and ratings/skill levels along another side. As teachers note a particular behaviour, they need only check the appropriate column that evaluates or rates the behaviour.

Checklists lend themselves very well to documenting such elements of the program as:

- understanding of a concept when using a manipulative
- mastered knowledge, skills or process
- work habits
- problem-solving strategies
- social skills.

CLARIFICATION/EXAMPLE

Checklist/Inventory of Social Skills

Behaviour to be Observed	Frequently	Sometimes	Never
Is sensitive to the needs and problems of others.			
Willingly shares ideas/materials.			
Accepts suggestions and help.			
Adheres to group plans/decisions.			
Works cooperatively with others.			
Respects the property of others.			
Appears to like group work.			

A variety of inventories/checklists useful in monitoring the development of problem-solving skills are provided in the "Problem Solving" section of this manual:

- Attitude Inventory Items
- Observational Checklist of Problem-Solving Attitudes and Behaviours
- Observational Rating Scale of Problem-Solving Attitudes and Behaviours
- Checklist of Problem-Solving Strategies
- Problem-Solving Strategy Inventory.

Similar checklists can be developed to monitor and evaluate other components of the mathematics program.

e.g., – use of estimation strategies
– facility with mental arithmetic.

Checklists and inventories can also be used to evaluate the products/outcomes of activities such as laboratory reports, oral presentations, library research and projects involving design and construction. By establishing indicators of outcomes along a scoring scale, a variety of different evaluation matrices that are appropriate to specific situations can be developed.

CLARIFICATION/EXAMPLE

SAMPLE EVALUATION MATRIX

Activity / Score	Problem-Solving Skills	Participation	Product (e.g., laboratory report, oral presentation, collage, model)
5	• Understands problem/ investigation/issue/ assignment • Selects necessary strategies • Evaluates appropriateness of solution/conclusion/opinion/ product	• Gets involved quickly • Stays involved	• Complete and correct • Commands respect • Neatly done
4	• As above but fails to evaluate solution/conclusion/opinion/ product	• Needs a start • Stays involved	• Mostly complete • Correct and neat • Good work
3	• Errors evident but strategies selected led to a solution/ conclusion/opinion/product	• Needs periodic reminding to stay on task	• Somewhat complete • Minor errors • Satisfactory
2	• Errors evident • No solution/conclusion/opinion/ product provided	• Needs constant reminding to stay on task	• Incomplete • Major errors • Untidy
E	Acceptably Excused from the Assignment		
0	Not Done or Handed in		

Other checklists and inventories that can be used to document particular elements of the science program are provided at the end of this section in:

- Resource 5: Inventory of Inquiry Skills/Attitudes
- Resource 6: Checklist for Assessing Writing Assignments.

Teachers may wish to modify and adapt these checklists in order to monitor and evaluate other components of the science program.

ANECDOTAL RECORDS

Anecdotal records refer to the spontaneous documentation of notable behaviour, effort and achievement. These records provide specific and dated information that can form the basis for conclusions and assessments. Anecdotal records often prove invaluable in clarifying assessments and add credibility to observations and recommendations being offered in student, parent and/or teacher meetings.

Anecdotal records may include observations on:

- attitude/work habits
- social skills
- effort and homework
- changes in performance
- specific strengths/deficiencies
- communication skills.

CLARIFICATION/EXAMPLE

Anecdotal Record Card

Student: Sue Jones

Date: 04/10

Comments:

- demonstrates an understanding of concepts studied through questions that she asks
- follows directions accurately, but is unable to establish/plan her own procedures for an investigation
- shows interest in helping others; excellent group worker
- has difficulty in selecting laboratory apparatus that is appropriate to a particular task

Anecdotal records may be kept in a daily or weekly diary, in student files, in the marks' record book or in a common file of short, dated notes.

INDIVIDUAL AND GROUP PROJECTS

Individual and group projects provide opportunities for students to demonstrate their ability to use a variety of skills through activities that may involve research in the library/community, experimental work in the laboratory or combinations of these and other activities. Students usually enjoy project work as it provides them with an opportunity to direct their own learning. Teachers should be prepared to assist students in planning their projects and in obtaining information, materials and equipment that may be required.

The quality of student work will be improved if students understand the criteria on which their projects will be evaluated. Teachers may wish to evaluate students in terms of their ability to:

- plan and design the project
- use appropriate processes/skills.

CLARIFICATION/EXAMPLE

Criteria for Evaluating a Plan/Design

Criteria	Score
Devises a good plan for research/investigation. Plan is clear, concise and complete.	9 - 10
Devises a plan for research/investigation that needs some modification. Understands the overall approach.	7 - 8
Devises an acceptable plan for research/investigation with some help.	5 - 6
Devises an inappropriate plan for research/investigation that needs considerable modification. Does not understand purpose/overall approach.	3 - 4
Has little idea of how to plan for research/investigation. Must be directed through each step.	1 - 2

CLARIFICATION/EXAMPLE

Criteria for Evaluating Process and Skill

Criteria — Score

A. Creative Thought 10

Does the project show creative/original thought in:
- questions asked?
- the approach to problem solving?
- the analysis/interpretation of data?
- use of equipment?
- the construction/design of a device or process?

B. Scientific Thought 10

Does the project display an understanding of:
- the purpose/problem?
- a procedural plan?
- variables and controls?
- conclusions that may be drawn from data collected?
- the limitations of data collected?

C. Strategies and Skills 10

Did the student:
- demonstrate knowledge and skill in using necessary equipment?
- use locally available sources of information?
- complete the project with minimal assistance?
- understand and use appropriate technical vocabulary?
- complete the project in a neat and orderly manner?

D. Thoroughness/Clarity 10

Does the project:
- carry out its purpose to completion?
- have appropriate notes/diagrams/illustrations?
- present data clearly and in sequential order?
- explain itself?

Can the student:
- discuss the project?
- explain the purpose, procedure and conclusions in a clear and concise manner?

WRITTEN ASSIGNMENTS

LABORATORY WRITE-UPS AND REPORTS

Students may be asked to demonstrate their understanding of concepts and skills by preparing laboratory write-ups and other written reports. Guidelines for evaluating these kinds of written assignments are provided throughout other sections of this manual and include:

- An Evaluation Guide for Lab Reports (see Nature of Science).
- An Evaluation Guide for Observations (see Nature of Science).
- An Evaluation Guide for Summarizing (see Communication Skills).
- An Evaluation Guide for Writing Directions (see Communication Skills).
- An Evaluation Guide for Informal Essay Writing (see Communication Skills).

DIAGNOSTIC WRITING ASSIGNMENTS

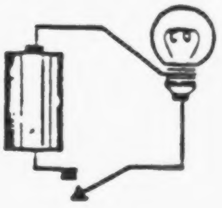
Diagnostic writing assignments require students to respond to questions in an expressive writing style. Written responses often force the student to examine their own understanding of concepts and will communicate to teachers how much students really know about a concept. Written responses also provide insight into how the student thinks. These assignments have proven successful as a diagnostic tool. Appropriate remedial and enrichment activities may be determined on the basis of the understanding demonstrated for a given concept.

CLARIFICATION/EXAMPLE

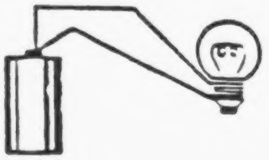
Applying Knowledge of Electrical Circuits

Circle the diagram below that represents a closed circuit. Explain why each of the other diagrams do not represent closed circuits, and how you would make the lamp work in each situation.

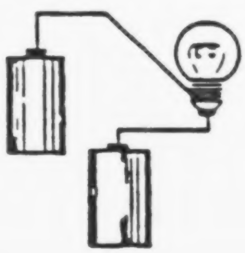
A.



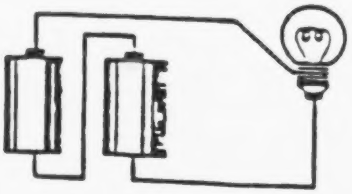
B.



C.



D.



These kinds of writing assignments should not be graded for a mark but, rather, be assessed for understanding (diagnosis). Students might be awarded bonus points based on their effort and presentation.

CLARIFICATION/EXAMPLE

0 points – no effort
1 point – mediocre attempt with little or no understanding
2 points – good attempt, but with some lack of understanding
3 points – high level of effort and understanding

Diagnostic writing assignments can be kept in a student diary or logbook, and might be assigned on a regular basis (once or twice a week) or in lieu of a regular quiz.

PAPER-AND-PENCIL TESTS

Traditional paper-and-pencil tests are probably the most widely used method of evaluating student performance. While effective in assessing factual and procedural knowledge, these tests often elicit feelings of inadequacy and self-doubt for students who have experienced previous difficulty or failure. These negative feelings affect test performance and may cause a cycle of repeated failure to continue.

Students may have learned the information presented in class, but are unable to demonstrate the knowledge because of poor reading skills, visual perception problems, inadequate reasoning and comprehension, fine-motor difficulties or other related deficiencies. Special needs of the student can be met through minor alterations in the construction of teacher-made tests. Constructing tests according to special needs can mean the difference between success and failure of some students.

The suggestions that follow will assist teachers to construct their tests according to the needs of individual students.

TEST DIRECTIONS

- Keep directions simple and avoid unnecessary words.
- Define words that are unfamiliar or abstract.
- Give an example of how the student is to respond whenever possible.
- Avoid oral directions as the only means of communication. Read directions orally as well as clearly writing them on the test.

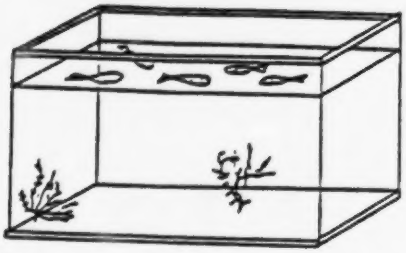
TEST ITEMS

- Provide manipulative materials that make situations more concrete whenever possible.
- Avoid mixing different question formats in the same section of the test.
- Design questions that:
  - are relevant to the student's personal experience
  - consist of simple sentences and familiar words.
- Underline or circle key words in a question.
- Ask students to circle the correct response in multiple choice items. This reduces the possibility of copying errors when transferring letters to blanks. Arrange the answer and distractors vertically on the page.

- Keep all matching items brief, and have only one correct answer for each item. Use no more than ten items in the matching lists. If you have more than ten items, group them by concepts in clusters of ten.
- Provide visual prompts that will assist students to recall and process information.

CLARIFICATION/EXAMPLE

Write two hypotheses you might make on the basis of this picture.



TEST DESIGN

- Construct the test in logical sequential order, from simple to complex problems.
- Use test items that reflect the content taught and techniques used to teach.
- Prepare a study guide for the test that matches the design of the actual test.
- Design the test to reflect the student's knowledge rather than ability to follow complicated directions, to use difficult vocabulary, or to work under time constraints.
- Adjust the readability level of the test to meet student needs.
- Prepare the test in short sections that can be administered individually if necessary.

RESOURCE 1: OBSERVATIONAL CHECKLIST OF STUDENT BEHAVIOURS

LEVEL OF INDEPENDENCE WITH WORK:

	ALWAYS	OFTEN	SOMETIMES	NEVER
• Settles down to work upon entering class.				
• Spends time on task; has satisfactory attention span.				
• Takes responsibility for making up work after absences.				
• Takes responsibility for supplies and equipment.				
• Follows directions; completes tasks with minimal assistance.				
• Asks for and accepts help when needed.				
• Accepts a challenge; works productively on tasks of increasing difficulty.				
• Displays self-confidence and pride in work.				

UNDERSTANDING OF CONCEPTS AND SKILLS:

• Uses the necessary vocabulary and concepts.				
• Uses appropriate operations, strategies and principles.				
• Asks questions, volunteers answers.				
• Answers questions that involve thought (e.g., What do you think?).				
• Demonstrates understanding through ability to generalize and apply.				
• Displays curiosity about objects, events, concepts and relationships.				
• Works independently on projects and research.				

ABILITY TO INVESTIGATE AND SOLVE PROBLEMS:

	ALWAYS	OFTEN	SOMETIMES	NEVER
• Understands and defines problems/issues.				
• Develops a systematic plan of attack.				
• Gathers information using a variety of sources.				
• Carries out plans and procedures, seeking help when necessary.				
• Uses appropriate strategies and processes.				
• Considers alternatives before reaching a solution/decision.				
• Evaluates solutions to the problem and decisions made.				
• Considers other ideas/opinions/solutions.				
• Defends personal statements/position on the basis of logical evidence.				

INTERPERSONAL SKILLS AND SOCIAL GROWTH :

• Resists aggressive and impulsive behaviours.				
• Volunteers to work in group situation.				
• Cooperates and contributes to group goals.				
• Listens to peers; considers the opinions of others.				
• Participates in oral discussions.				
• Willingly helps others.				

RESOURCE 2: GAINING INFORMATION FROM TEXT

Select a chapter of a science textbook. The textbook should be one currently in use in the student's science program.

WORD IDENTIFICATION

Ask the student to read aloud a passage of about 200 words. Note the number of words identified correctly. __% of words are identified correctly.

If the student identified 90% or more of the words correctly, proceed with the interview. If the student identified less than 90% of the words correctly, select an easier textbook. Hesitations and self-corrections should not be counted as errors.

SURVEY OF STRATEGIES

Ask the student to show you how he/she would study the chapter in order to gain information. Ask him/her to verbalize his/her thoughts during the course of reading. Note the strategies employed by placing a check (✓)in the blank space.

- Skimmed: introduction _____
  - headings _____
  - figures and illustrations _____
  - italics _____
  - conclusion _____

  prior to reading the chapter
- Read the chapter from beginning to end _____
- Began to read chapter, then gave up _____
- Spontaneously asked himself/herself questions while reading _____
- Used study questions as a guide for reading _____
- Picked out the main ideas or important points while reading _____
- Paraphrased main ideas or important points _____
- Looked up unknown words in the dictionary _____
- Underlined or highlighted important information _____
- Made notes _____

Other: ____

____

____

____

PROBES

Some students have strategies in their repertoire that they do not use unless directed to do so. Select a different chapter in the same textbook and rate the student's skill on the following directed procedures.

	Excellent	Adequate	Inadequate	Notes
Getting appropriate information from: introduction headings figures and illustrations italics conclusions Self-questioning Paraphrasing of main ideas Identifying words not understood Looking up words in the dictionary				

Comments: ______________________________

____

____

____

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RESOURCE 3: INTERVIEW GUIDE FOR INQUIRY/PROBLEM SOLVING

1. Establish rapport to help the student feel comfortable.

2. Ask the student to "talk about what he or she is doing or thinking" while conducting an investigation or solving a problem. Explain that this will enable you to help the student to develop effective inquiry/problem-solving strategies.

3. As the student attempts to understand the problem and design procedures, observe the student and ask questions such as the following, if appropriate:

   a. What did you do first when given the problem? Next?
   b. What are the important facts and conditions in this situation? Do you need to obtain additional information that has not been provided?
   c. Is there anything you don't understand about the problem or situation?

4. As the student develops and carries out a plan, remind him or her again to talk about it and ask questions such as the following, if appropriate:

   a. What do we want to investigate/explain/construct?
   b. What do you think might happen if . . .?
   c. What is the relationship between . . . and . . . ?
   d. What strategy are you using? Have you thought about using other strategies? Which ones?
   e. Where are you having difficulty? What should you do next?

5. As the student proceeds to carry out the plan, observe the ways, if any, in which he or she monitors and evaluates progress. Ask questions such as:

   a. What caused . . . to happen?
   b. What does the data indicate?
   c. Are you sure this is the correct answer to the problem? Why?
   d. Do you think it is important to check your answer? Why?

6. After the student has solved the problem, ask questions such as:

   a. Can you describe your findings/outcomes?
   b. Is this problem like any other problem you've solved? How?
   c. Do you think there are other ways of dealing with this situation? What are your ideas?
   d. How could you make your work easier another time?
   e. How did you feel while you were solving this problem? How do you feel now that you have found a solution?

RESOURCE 4: INTERVIEW GUIDE FOR PROJECT WORK

THE TASK ENVIRONMENT

1. How did you select this investigation/project? ____________________

____

2. Are you interested in it?
____ very ____ somewhat ____ not at all

3. What did the teacher do when giving out the assignment? ____________________

____

Examples:
- give verbal guidelines
- give written guidelines
- select the topic
- provide a strategy
- increase your interest

4. Who do you expect will examine the results of your investigation/project? ____________________

____

PREVIOUS KNOWLEDGE

5. Have you undertaken an investigation/project like this before?
____ yes ____ no

6. What did you know about this topic before you started? ____________________

____

7. Which of the following scientific processes did you use in carrying out your investigation/project?

______ recognizing patterns
______ defining problems
______ predicting events
______ performing experiments
______ controlling variables
______ taking measurements
______ using arithmetic
______ making inferences
______ making a model
______ gathering information
______ formulating hypotheses
______ making a plan
______ collecting data
______ making observations
______ organizing data
______ classifying
______ identifying cause/effect
______ making decisions

PLANNING

8. How did you plan your investigation/project? ____________________

____

RESOURCE 4: INTERVIEW GUIDE FOR PROJECT WORK (cont'd)

9. Did you make an outline of the steps you would take?

___ yes _____ no

What kind of thinking did you do first? ___________

____

10. Did you do any research? _____ yes _____ no

What sources of information did you use? ______________________________

____

REVIEWING AND APPLYING

11. What strategies did you find most helpful in completing your investigation/project?

Examples:

_____ reading
_____ following directions received
_____ explanations from the teacher
_____ studying diagrams/models
_____ performing experiments
_____ watching films/filmstrips
_____ having a group discussion
_____ listening to a guest speaker
_____ other

12. Explain three ways that you might make use of the results of your investigation in everyday life.

____

____

____

EVALUATING

13. What have you learned in completing this investigation/project? ______________

____

14. What grade did you think you would get? ______________________________

Why? ______________________________

15. What was the teacher's evaluation? ______________________________

How was this evaluation different from your anticipated grade? ______________

____

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RESOURCE 5: INVENTORY OF INQUIRY SKILLS/ATTITUDES

INQUIRY SKILLS:

	Applies Skill Independently	Needs Periodic Assistance	Needs Constant Assistance	Does Not Participate
• Asks questions about natural phenomena.				
• Formulates problems/makes hypotheses.				
• Designs/conducts experiments.				
• Makes inferences/predictions.				
• Makes/records accurate observations.				
• Makes comparisons.				
• Uses measurement skills.				
• Classifies objects in a variety of ways.				
• Uses appropriate methods to gather/record information.				
• Interprets tables/charts/graphs.				

INQUIRY ATTITUDES:

	Consistently	Frequently	Occasionally	Rarely
• Shows interest in studying natural phenomena.				
• Demonstrates an objective attitude by considering evidence for and against an idea.				
• Demonstrates curiosity about observations by asking questions and conducting investigations.				
• Demonstrates, through discussion, an understanding of the differences between hypotheses, solutions, facts and inferences.				
• Changes an opinion when confronted with evidence.				
• Appreciates that a correlation does not necessarily mean a cause and effect relationship.				
• Critically examines experimental procedures and outcomes.				

RESOURCE 6: CHECKLIST FOR ASSESSING WRITING ASSIGNMENTS

IDEAS AND ORGANIZATION:

	Excellent	Adequate	Inadequate	Not Applicable
• Understands the purpose of the writing activity.				
• Uses an appropriate title.				
• Uses pre-writing activities to plan work.				
• Demonstrates an understanding of content.				
• Chooses an organizational pattern that suits the purpose.				
• Writes a clear/concise topic sentence.				
• Provides supporting details and examples.				
• Expresses ideas in an appropriate sequence.				
• Clarifies ideas by using pictures/charts/diagrams.				
• Concludes assignment by recalling the main points and summarizing.				

EXPRESSION AND MECHANICS:

	Excellent	Adequate	Inadequate	Not Applicable
• Uses appropriate vocabulary.				
• Avoids spelling errors.				
• Includes sentence variety.				
• Avoids shifts in personal pronoun use/verb tense.				
• Maintains agreement of person, number and gender in subject and verb.				
• Uses correct punctuation.				
• Completes assignments legibly and neatly.				

APPENDIX A: ANNOTATED LIST OF VIDEO RESOURCES

The video resources described below are available through ACCESS NETWORK and/or Regional Resource Libraries. Their listing is not to be construed as an explicit or implicit departmental approval for use. These titles are provided as a service only to assist local jurisdictions in identifying potentially useful learning resources. The responsibility for evaluating each resource prior to selection rests with the local jurisdiction.

Acme School of Stuff (Series). Toronto, Ontario: TV Ontario, 1988. A series of thirteen 25-minute programs that explore the science and technology in everyday items. The host uses a variety of household objects and homemade gadgets to provide explanations of technological products and processes. Very effective in demonstrating the relationship between science and technology.

Program 01 – deals with cassette tapes, chocolate and microwave ovens
Program 02 – deals with telephones, sewage treatment and video
Program 03 – deals with batteries, water and fuel injection
Program 04 – deals with records, neon and the cathode-ray tube
Program 05 – deals with light bulbs, the Canadian Standards Association and modems
Program 06 – deals with electricity, glass bottles and brakes
Program 07 – deals with history, manufacturing and testing of the toilet
Program 08 – deals with cable television, the subway and engineering
Program 09 – deals with traffic signals, a natural gas pipeline and alternating current
Program 10 – deal with digital computers, folding paper cartons and the electric shaver
Program 11 – deals with electronics, the body shop and coin units in vending machines
Program 12 – deals with composite substances, piano rolls and automobile alignment
Program 13 – deals with engines, wire and satellites

Chemistry in Everyday Life. Britannica, 1987. A 15-minute video that illustrates practical applications of chemistry in everyday life. Fosters an understanding of the composition, structure and properties of familiar substances, as well as transformations they undergo. Effective in helping students to understand the science of chemistry.

Farewell, Ancient Mariner. Canadian Filmmakers. A 26-minute video that explores problems associated with the threatened extinction of the sea turtles. Focuses attention on the activities of environmental groups such as Greenpeace in attempting to curb consumption of these animals and rescue them from habitats under destruction.

Greenhouse Effect. Canadian Broadcasting Corporation, 1984. A 30-minute video that explores the causes and consequences of the Greenhouse Effect.

The Human Body Series. Mississauga, Ontario: National Geographic, 1988. A series of 17-minute videos that explore the functioning of different systems within the human body. Videos within the series that are particularly relevant to Science 16 include *Circulatory and Respiratory Systems*, *Digestive System*, *Muscular and Skeletal Systems* and *Nervous Systems.*

The Problem-Solving Film. Omega, 1988. An 18-minute video that demonstrates how critical thinking skills are vital to solving practical problems. Uses a humorous analogy of how detectives solve a case to illustrate appropriate strategies for solving problems. Effective in providing structure for problem-solving activities.

Science Edition II. TV Ontario, 1987. A 50-minute video that explores impacts of science and technology on society. Focuses particular attention on artificial limbs, the technology of neon, basic genetic engineering and developments in visual aid.

The Scientific Method. VEC, 1987. A 23-minute video that traces the evolution of knowledge gained through the scientific method. Demonstrates the processes of observation, theorizing or hypothesizing, and testing the hypothesis through experimentation. Effective in helping students to understand the nature of the scientific enterprise.

Simple Machines. Kinetic Incorporated, 1988. A 15-minute video that explains the operation of six simple machines and other mechanical systems that consist of combinations of simple machines. Focuses attention on the importance of machines in our everyday lives.

APPENDIX B: GOVERNMENT AGENCIES

The government agencies listed below may be able to provide various types of information relevant to learning objectives within the science program.

Alberta Alcohol and Drug Abuse Commission (AADAC)
8th Floor, Energy Square Building
10109 - 106 Street
Edmonton, Alberta
T5J 3L7
Telephone: 427-4267

Alberta Consumer and Corporate Affairs
3rd Floor, Capilano Centre
9945 - 50 Street
Edmonton, Alberta
T6A 0L4
Telephone: 427-5782

Alberta Economic Development and Trade
6th Floor, Sterling Place
9940 - 106 Street
Edmonton, Alberta
T5K 2P6
Telephone: 427-0670

Alberta Energy
2nd Floor, Highfield Place
10010 - 106 Street
Edmonton, Alberta
T5J 3L8
Telephone: 427-5200

Alberta Technology, Research and Telecommunications
12th Floor, Pacific Plaza
10909 Jasper Avenue
Edmonton, Alberta
T5K 2J6
Telephone: 422-0567

Alberta Transportation and Utilities
Twin Atria Building
1999 - 98 Avenue
Edmonton, Alberta
T6B 2X3
Telephone: 427-7674

Environment Council of Alberta
8th Floor, Weber Centre
5555 Calgary Tail, Southbound NW
Edmonton, Alberta
T6H 5P9
Telephone: 427-5792

APPENDIX C: REGIONAL OFFICES OF EDUCATION

Grande Prairie Regional Office

12th Floor, 214 Place
9909 - 102 Street
Grande Prairie, Alberta
T8V 2V4
Telephone: 538-5130
FAX: 538-5135

Edmonton Regional Office

7th Floor, Westcor Building
12323 Stony Plain Road
Edmonton, Alberta
T5N 3Y5
Telephone: 427-2952
FAX: 422-9682

Red Deer Regional Office

3rd Floor West, Provincial Building
4920 - 51 Street
Red Deer, Alberta
T4N 6K8
Telephone: 340-5262
FAX: 340-5305

Calgary Regional Office

Room 1200, Rocky Mountain Plaza
615 Macleod Trail, S.E.
Calgary, Alberta
T2G 4T8
Telephone: 297-6353
FAX: 297-3842

Lethbridge Regional Office

Provincial Building
200 - 5th Avenue, South
Lethbridge, Alberta
T1J 4C7
Telephone: 381-5243
FAX: 381-5734

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Alberta Education and Bernie Galbraith for adaptations from *Science Process Skills and the Alberta Science Curriculum (A Position Paper)*, 1983.

Alberta Environment for illustrations from the *Focus On Series*.

Athabasca Health Unit for adaptations from *Facts About Food* and *Nutrition and Athletic Performance*.

Dr. C. Bos and S. Baughn for an excerpt from *Strategies for Teaching Students with Learning and Behaviour Problems*. Copyright 1988 by Boston, Allyn and Bacon. Reprinted by permission of the authors.

British Columbia Ministry of Education for excerpts from the *Junior Secondary Science Curriculum Guide and Resource Book*, 1983.

Canadian Dietetic Association for permission to reproduce the *Body Mass Index*.

Federated Co-operatives Limited for excerpts from *Consumer's Guide, Co-op Consumer Counsellor*, 1983.

Glencoe Publishing Company for excerpts from *General Industrial Education* by Los Angeles Unified School District, 1988.

Learning Disabilities Focus (Publisher) for adaptations from *Alternatives in the Assessment of the Learning Disabled Adolescent: A Learning Strategies Approach* by Judith Wiener, 1986. Adapted by permission of the publisher.

Manitoba Department of Health for excerpts from *How Do Your Meals Score*?

Mulcahy, Marfo, Peat and Andrews for adaptations from *SPELT: A Strategies Programme for Effective Learning/Thinking: Inservice Edition*, SPELT International Limited, 1987. Reprinted by permission of the authors.

University of the State of New York/State Education Department for adaptations from *Science Syllabus for Middle and Junior High Schools (Block J: Science, Technology and Society)*, 1985.

James H. Wandersee for adaptations from *Drawing Concept Circles: A New Way to Teach and Test Students*, 1987. Adapted by permission of the author.

Appendix 16

END

U.S. Dept. of Education

Office of Education
Research and
Improvement (OERI)

ERIC

Date Filmed

March 29, 1991